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REPORT

OF THE

NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1883.

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1884.

REPORT

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OF THE

NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1883.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

LETTER OF TRANSMITTAL.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., January 10, 1884.

SIR: In conformity with the requirements of the act of incorporation, approved March 3, 1883, I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year.

Very respectfully, your obedient servant,

O. C. MARSH,
President of the National Academy of Sciences.

To the PRESIDENT OF THE SENATE.

REPORT

OF

THE NATIONAL ACADEMY OF SCIENCES.

The National Academy of Sciences was established by act of Congress, in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

The object of the Academy is to advance science, and especially to investigate, examine, experiment, and report on any subject of science or art whenever called upon by any department of the Government.

The Academy contains, at present, about one hundred members, and these have all been selected for their original researches in science. They represent within their ranks nearly every department of knowledge, and their services, in accordance with the charter of the Academy, are always at the disposal of the Government, without compensation.

SESSIONS OF THE NATIONAL ACADEMY.

During the past year the Academy has held three sessions. The first was the regular annual session, held in Washington, April 17 to 20, 1883; the second was a scientific session, in New Haven, Conn., November 13 to 16, 1883; and the third was a special session, in New Haven, November 14, 1883.

STATED SESSION.

HELD IN WASHINGTON CITY, APRIL 17 TO 20, 1883.

The Washington session was held in the National Museum, the vice-president, Prof. O. C. Marsh, presiding.

In the absence of the home secretary, Mr. Newcomb, Mr. Asaph Hall was elected secretary *pro tem.*

The following members were present during the session:

Abbe.
Abbot.
Agassiz.
Baird.
Barker.
Brewer.
Coffin.
Cooke.
Cope.
Ferrel.
Gibbs.
Gill.
Hall.
Hayden.
Hilgard, J. E.
Hill.
Humphreys.
Hunt.
Langley.
Marsh.
Meigs.
Mitchell.
Peirce.
Peters.
Powell.
Pumpelly.
Remsen.
Rowland.
Schott.
Scudder.
Silliman.
Trowbridge, J.
Trumbull.
Wright.
Young.

Prof. Otto von Struve, astronomer royal of Russia, and his son, Dr. Hermann von Struve, were invited to attend the meeting and present papers.

At this session the following papers were read and discussed:

1. Le Conte, Joseph.—On the Genesis of Metalliferous Veins. Read by Mr. Hunt.
2. Remsen, Ira.—On the Nascent State of Oxygen. Discussed by Mr. Hunt.
3. Loomis, Elias.—On Barometric Gradients. Read by Mr. Abbe. Discussed by Messrs. Ferrel, Abbe, and Coffin.
4. Cope, E. D.—On the Structure of the Skull in the Hadrosauridæ. Discussed by Mr. Marsh.
5. Hill, G. W.—Determination of the Inequalities of the Moon's Motion which are produced by the Figure of the Earth. A supplement to Delauney's "Theorie du Mouvement de la Lune."
6. Hunt, T. Sterry.—On the Decay of Rocks geologically considered.
7. Mitchell, S. Weir, *and* Reichert, E. T.—On the Composition of the Venom of Serpents. Discussed by Messrs. Barker, Remsen, and Gibbs.
8. Ferrel, W.—Maxima and Minima Tide Predicting Machine. (Exhibition of the machine.)
9. Remsen, Ira.—On Changes in the Properties of Atoms and Atomic Groups, caused by change in position in the Molecule.
10. Langley, S. P.—On the Measurement of Wave Lengths of Heat. Discussed by Messrs. Rowland and Young.
11. Langley, S. P.—On the Spectrum of an Argand Gas-Burner. Discussed by Messrs. Barker, Gill, Abbot, and Rowland.
12. Barker, Geo. F.—Efficiency of Storage Batteries. Discussed by Mr. Bell.
13. Struve, Otto von.—(By invitation of the Academy.) On the great Object Glass made by Alvan Clark & Sons for the Pulkowa Observatory. Discussed by Messrs. Hall, Marsh, and Peters.
14. Peters, C. H. F.—Photographs of the Great Comet of 1882. Discussed by Mr. Hall.
15. Wright, A. W.—Some Experiments upon a Method of forming a Visible Image of the Solar Corona.
16. Wright, A. W.—On the Phosphorescence of Sulphate of Quinine. Discussed by Messrs. Hall and Barker.
17. Gibbs, Wolcott.—Further generalizations regarding Complex Inorganic Acids. Read by Mr. Barker.

ELECTIONS.

Prof. O. C. Marsh, vice-president, was elected president to fill the vacancy caused by the death of President William B. Rogers.

Prof. Simon Newcomb, home secretary, was elected vice-president.

Prof. Asaph Hall, secretary *pro tem.*, was elected home secretary.

The following members were selected for the council of the ensuing year: Messrs. S. F. Baird, W. Gibbs, J. E. Hilgard, M. C. Meigs, F. Rogers, C. A. Young.

NEW MEMBERS.

The following new members were elected: Messrs. A. Graham Bell, John S. Billings, Henry B. Hill, Grove K. Gilbert, Charles L. Jackson.

FOREIGN ASSOCIATES.

The following gentlemen were elected foreign associates: Messrs. J. C. Adams, Arthur Auwers, M. P. E. Berthelot, J. L. F. Bertrand, J. B.

J. D. Boussingault, Arthur Cayley, M. E. Chevreul, Rudolph Clausius, Alphonso De Candolle, J. B. Dumas, Baron H. von Helmholtz, Sir J. D. Hooker, T. H. Huxley, G. R. Kirchoff, Albert von Kölliker, Theodore von Oppolzer, Louis Pasteur, F. von Richthofen, G. G. Stokes, Otto von Struve, J. J. Sylvester, Sir William Thomson, Rudolph von Virchow, Adolphe Würtz.

TREASURER'S REPORT.

The treasurer presented the following report, which had been examined by the auditing committee, Messrs. Schott and Abbe, and approved:

1. *General account, April* 18, 1882, *to April* 16, 1883.

RECEIPTS.

Cash balance from last year		$340 58
Dues collected from members		530 00
Interest on District of Columbia 3.65 bond		36 50
Total assets		907 08

EXPENDITURES.

Stationery, printing, and postage	$157 11	
Copying	30 00	
Expenses of April and November meetings	258 99	
Rent and care of library room	121 00	
Expenses of committee on sorghum	109 31	
		676 41
Cash balance on hand April 16, 1883		230 67
Dues from members		30 00
District of Columbia 3.65 bond		1,000 00
Total assets		1,260 67

2. *The Bache trust fund.*

RECEIPTS.

Cash balance from last year, including $43.18 of uninvested capital		$3,344 70
Income receipts during year		2,306 85
Drawback of special assessments on Washington House		36 62
$9,850 United States loan, 3½ per cent., called and redeemed		9,850 00
Total		15,538 17

EXPENDITURES.

Appropriation by directors of Bache fund	$1,200 00	
Taxes on Missouri land	18 65	
Cost of $9,900 United States loan, 4½ per cent., of which $59.10 is accrued interest	11,236 50	
Cost of $1,500 District of Columbia loan, 3.65 per cent., of which $22.75 is accrued interest	1,668 75	
		14,123 90
Balance of income fund, cash		1,414 27
Add District of Columbia loan, 3.65 per cent		4,500 00
		5.914 27

The changes of investments during the year are as follows:

United States loan, 3½ per cent., called and redeemed	$9,850 00
United States loan, 4½ per cent., purchased	9,900 00
Increase, previously uninvested, $43.18; from income fund, $6.82	50 00
	19,800 00

3. *The Watson fund.*

RECEIPTS.

Cash from L. Gruner, executor of the estate of James C. Watson	$7,050 25
Dividend on stock of Michigan Mutual Life Insurance Company	768 75
Interest on $6,000 United States loan, 4½ per cent	139 50
	7,958 50

EXPENDITURES.

Appropriation by Board of Trustees for total solar eclipse, May 6, 1883	$300 00	
Cost of $6,209 United States loan, 4½ per cent., of which $23.25 is accured interest	7,013 75	
		$7,313 75
Balance		644 75

INVESTMENTS.

United States loan, 4½ per cent	$6,200 00
One hundred and thirty-four shares of capital stock of Michigan Mutual Life Insurance Company, received from L. Gruner, executor, par	6,700 00
Total	12,900 00

J. H. C. COFFIN,
Treasurer.

The following report of the committee to examine securities held by the Academy was read and approved:

WASHINGTON, D. C., *April* 11, 1883.

The committee, Messrs. Meigs and Gill, appointed at the April session, 1882, of the National Academy of Sciences to examine securities in the hands of the treasurer, report that they have examined said securities, and find they are as follows:

1. *Bache trust fund.*

United States loan, 4½ per cent	$42,100
United States loan, 4 per cent	3,850
City of Davenport loan, 6 per cent., coupon	1,000
City of Philadelphia loan, 6 per cent	600
	47,550

Also a deed for 160 acres of Missouri lands.

Also an agreement with the Pennsylvania Company for the insurance on lives and granting annuities as to the final disposition of the Joseph Henry fund of $40,000.

2. *Income of the Bache fund.*

District of Columbia 3.65 per cent. ($500 of which are coupon)	$4,500

3. *General fund.*

District of Columbia 3.65 per cent	1,000

4. *Watson trust fund.*

United States loan, 4½ per cent	$6,200
Certificate for 134 shares of capital stock of the Michigan Mutual Life Insurance Company, par	6,700
	12,900

Mrs. James C. Watson claimed, and was allowed, under the law of Wisconsin, one-third of the estate of her late husband in lieu of the bequests made her.

THE HENRY DRAPER MEDAL.

The president announced that Mrs. Henry Draper, widow of Dr. Henry Draper, late an honored member of the Academy, had presented to the National Academy of Sciences a fund of $6,000 for the establishment of a gold medal to be awarded every two years to the individual in this or any country who makes the most important discovery in astronomical physics, the value of said medal to be $200, and the fund, in case the medal should not be awarded, to be applied by the Academy to investigations in the same department of science.

DEATH OF MEMBERS.

The president announced the death of a member of the Academy, Dr. Henry Draper, who died in New York, November 20, 1882.

Mr. G. F. Barker was appointed to prepare an obituary memoir.

RESOLUTIONS.

The following resolutions from the council were adopted:

It was resolved that the assessment for the ensuing year be $5.

Resolved, That the secretary be directed to acknowledge, with thanks, the invitation extended to the Academy by the Royal Society of Canada to send delegates to the meeting to be held at Ottawa, May 22, 1883.

The president appointed Mr. Hunt to represent the National Academy of Sciences at said meeting.

The treasurer, Mr. Coffin, presented the following resolution in regard to the bequests of the late James C. Watson, which was adopted:

Resolved, That the National Academy of Sciences accepts the bequests of the late James C. Watson for the trust and purpose expressed in his will.

Resolved, That the Academy approves of the appropriation made by the Board of Trustees of $500, or as much of the same as may be necessary, to aid in the observation of the total solar eclipse on May 6, 1883.

Mr. Coffin moved that the deed of Mrs. Henry Draper be entered at length in the minutes of the meeting. The motion was adopted.

Resolved, That the acknowledgments of the National Academy of Sciences are due to the honorable Secretary of the Navy, the Chief of the Bureau of Navigation, and the Superintendent of the Naval Observatory for the interest they have manifested in the expedition for observing the total eclipse of the sun in May next, organized under the direction of a committee of the Academy, and for the important aid and facilities afforded by the Navy Department to promote and secure its success.

The following resolution was recommended by the council and adopted:

Resolved, That a permanent committee of five be appointed to consider the subject of the bestowal of the Henry Draper medal, and to recommend to the Academy, from time to time, such persons as they may consider deserving of the medal, with the ground of their recommendation.

Mr. Pumpelly moved that the committee be appointed by the president.

The motion was adopted, and the following members were appointed: Messrs. Barker, W. Gibbs, Newcomb, Wright, Young.

Mr. Abbe moved that Mr. Gill be reimbursed for expenses incurred in the preparation of the list of papers and publications of the Academy at the rate of twelve cents per hundred words. The motion was adopted.

Mr. Gill suggested that it would be well to have an account of what the Academy had done through the expenditures of its funds, and offered the following resolution:

Resolved, That the treasurer and those interested in the expenditures of moneys of the Academy should make a report of what had been done in the past twenty years.

The resolution was referred to the council with power.

The president appointed Mr. Meigs to fill the place made vacant by the election of Mr. Newcomb in the committee to represent the Academy before Congress.

The president also appointed the following committee on printing: Messrs. Baird, Coffin, and Newcomb.

REPORTS OF COMMITTEES.

Mr. Gill, who was appointed to prepare a complete list of all the publications of the Academy, presented a list of some 750 papers and publications, and moved that the home secretary be requested to co-operate in this matter, and furnish, in addition, the reports made by committees of the Academy to various Departments of the Government for incorporation with the said list. The motion was adopted.

The chairman of the committee on the election of foreign associates, Mr. Agassiz, presented twenty-five nominations to be voted on, and explained the manner in which they had been prepared.

The committees on alcohol and sorghum sugar, having made their reports, were discharged.

The Academy adjourned April 20, 1883.

SCIENTIFIC SESSION.

Held in New Haven, Conn., November 13 to 16, 1883.

A scientific session, for the reading of papers only, having been called by the council, as announced at the April session, the Academy convened at Yale College, New Haven, Conn., on November 13, 1883. The president, Prof. O. C. Marsh, presided.

The following members were present during the session:

Barker.
Bell.
Brewer.
Brush.
Coffin.
Cooke.
Dana.
Gibbs, J. W.
Gibbs, W.
Hall, A.
Hall, J.
Hunt.
Johnson.
Langley.
Loomis.
Marsh.
Morse.
Newberry.
Newcomb.
Newton, H. A.
Packard.
Pickering.
Powell.
Pumpelly.
Rowland.
Scudder.
Silliman.
Trowbridge, W. P.
Verrill.
Walker.
Wright.
Young.

The following gentlemen were invited to attend the meetings, and to take part in the scientific proceedings: Prof. W. D. Whitney, Prof. E. S. Holden, Dr. W. L. Elkin, Prof. Lewis Boss, Dr. C. S. Hastings, Mr. R. H. Chittenden, Dr. Carl Barus, Dr. William Hallock, Major McFarland, Corps of Engineers, U. S. A., and Mr. O. T. Sherman.

The following papers were read and discussed:

1. Bell, A. Graham.—Upon the formation of a Deaf Variety of the Human Race. Discussed by Messrs. Brewer, Bell, Powell, Scudder, and Newcomb.
2. Hall, A.—Notes on the Mass of Saturn. Discussed by Messrs. Newcomb, A. Hall, Young, Coffin, and Pickering.
3. Hunt, T. Sterry.—The Animikie Rocks of Lake Superior. Discussed by Messrs. Powell and Hunt.
4. Chittenden, R. H.—(By invitation of the Academy.) On some new primary Cleavage Forms of Albuminous Matter.
5. Young, C. A., *and* Coffin, J. H. C., *and* (by invitation) Holden, E. S., *and* Hastings, C. S.—On the Solar Eclipse of May 6, 1883. Reports. Discussed by Messrs. Young, Rowland, Newcomb, Hastings, Langley, and Wright.
6. Newcomb, S.—On the use of the word "Light" in Physics. Discussed by Messrs. Young, Langley, Newcomb, Pickering, and Bell.
7. Brewer, W. H.—On the Subsidence of Particles in Liquids. Discussed by Messrs. Rowland, Silliman, Brewer, Hunt, Newberry, J. W. Gibbs, Powell, and Johnson.
8. Rowland, H. A.—On a new Photograph of the Solar Spectrum. Discussed by Mr. W. Gibbs.
9. Langley, S. P.—Atmospheric Absorption. Discussed by Messrs. Pickering, Young, and Langley.
10. Newcomb, S.—On the Theory of Errors of Observation and Probable Results. Discussed by Messrs. Langley, Newcomb, Newton, Young, and J. W. Gibbs.
11. Gibbs, Wolcott.—Preliminary notice of Phospho-vanadates, Arsenio-vanadates and Antimonio-vanadates.
12. Gibbs, Wolcott.—On the probable existence of new Acids of Phosphorus.

13. **Hall, James.**—Note upon the Physical Aspects of the higher members of the Chemung Group and the development and distribution of the Fossil Genera, Ptychopteria and Leptodesma, preceded by a review of the Pectenidæ and Aviculidæ of the Devonian System. Discussed by Messrs. Newberry and Marsh.
14. **Silliman, B.**—Notes on the Mineralogy and Lithology of the Bodie Mining District of California.
15. **Newberry, J. S.**—On the ancient glaciation of North America.
16. **Powell, J. W.**—Marriage Institutions in Tribal Society.
17. **Sherman, O. T.**—(By invitation of the Academy.) Personality in the measures of Venus's diameter as derived during Transit across the Sun.
18. **Loomis, Elias.**—The reduction of Barometric Observations to Sea-level. Discussed by Mr. Brewer.
19. **Dana, J. D.**—On the Stratified Drift or Terrace Formation of the New Haven Region, including its Kettle Holes and deserted River Channels. Discussed by Mr. Newberry.
20. **Marsh, O. C.**—On the Affinities of the Dinosaurian Reptiles.

DEATH OF MEMBERS.

The president announced the death of the following members, who have died since the April meeting: Prof. Stephen Alexander, Prof. William A. Norton, Prof. J. Lawrence Smith, Dr. John Le Conte.

The following members were appointed to prepare obituary memoirs:

Of Professor Alexander: Prof. C. A. Young.

Of Professor Norton: Prof. William P. Trowbridge.

Of Professor Smith: Prof. B. Silliman.

Of Dr. Le Conte: Mr. S. H. Scudder.

Since the November meeting General A. A. Humphreys has died at Washington, D. C., December 28, 1883.

DEATH OF FOREIGN ASSOCIATES.

Since the November meeting, news has been received of the death of Prof. Joachim Barrande, foreign associate, who died October 5, 1883, at Frohsdorf, Austria.

The scientific session closed November 16, 1883.

SPECIAL SESSION.

Held in New Haven, Conn., November 14, 1883.

A special session of the Academy having been called by the council, in accordance with section 1, Article III of the constitution, the Academy convened at Yale College, New Haven, Conn., November 14, 1883, the president, Prof. O. C. Marsh, presiding.

The president was authorized to include in his annual report to Congress, with the proceedings of the April meeting, the proceedings of the November meeting, the report of the committee on the solar eclipse of May 6, 1883, and the report of the committee on glucose.

RESOLUTIONS.

Upon recommendation of the council, the following resolutions were adopted:

Resolved, That the president include in his annual report to Congress an expression of the approval of the Academy of the efforts now being made to secure a system of uniform time, such a system being free from objection on scientific grounds, and certain to prove a public convenience.

Resolved, That the president communicate to the honorable Secretary of the Navy, and include in the annual report to Congress, an expression of the high appreciation of the Academy of the generous and efficient aid rendered by the Navy Department to science in the observation of the solar eclipse of May last, by placing a ship at the disposal of the observing party, and making all arrangements necessary to secure the success of the expedition.

Resolved, That the president request the honorable Secretary of the Navy to communicate to Captain Carpenter and the officers of the Hartford the thanks of the Academy for the courtesies extended by them to the eclipse party while on board the ship, and for the energy and personal interest with which they co-operated in the work.

Resolved, That the thanks of the National Academy of Sciences be tendered to the Governing Board of the Sheffield Scientific School for the excellent arrangements made for the accommodation of the Academy during the session.

The special session then adjourned.

Respectfully submitted.

O. C. MARSH,
President of the National Academy of Sciences.

APPENDICES.

APPENDIX A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. B. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, Saint Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States Navy, District of Columbia; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania; J. L. Le Conte, United States Army, Pennsylvania; J. Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, junior, Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SECTION 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institutions, and to report the same to Congress.

SECTION 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the academy shall, whenever called upon by any Department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the academy shall receive no compensation whatever for any services to the Government of the United States.

Approved, March 3, 1863.

AN ACT to amend the act to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act to incorporate the National Academy of Sciences, approved March three, eighteen hundred and sixty-three, be, and the same is hereby, so amended as to remove the limitation of the number of ordinary members of said academy as provided in said act.

Approved, July 14, 1870.

DEPARTMENT OF STATE, *June* 10, 1882.

True copies.

SEVELLON A. BROWN,
Chief Clerk.

APPENDIX B.

CONSTITUTION AND RULES OF THE NATIONAL ACADEMY OF SCIENCES.

As amended and adopted April 17, 1872, and further amended April 20, 1875, April 21, 1881, April 19, 1882, and April 18, 1883.

PREAMBLE.

Empowered by the act of incorporation enacted by Congress, and approved by the President of the United States, on the 3d day of March, A. D. 1863, and in conformity with the amendment to said act, approved July 14, 1870, the National Academy of Sciences adopt the following amended constitution and rules:

ARTICLE I.—OF MEMBERS.

SECTION 1. The Academy shall consist of members, honorary members, and foreign associates. Members must be citizens of the United States.

SEC. 2. Members who, from age or inability to attend the sessions of the Academy, wish to resign the duties of active membership may, at their own request, be transferred to the roll of honorary members by a vote of the Academy.

SEC. 3. The Academy may elect fifty foreign associates.

SEC. 4. Honorary members and foreign associates shall have the privilege of attending the meetings and of reading and communicating papers to the Academy, but shall take no part in its business, shall not be subject to its assessments, and shall be entitled to a copy of the publications of the Academy.

ARTICLE II.—OF THE OFFICERS.

SECTION 1. The officers of the Academy shall be a president, a vice-president, a foreign secretary, a home secretary, and a treasurer, all of whom shall be elected for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner at the session when such vacancy occurs, or at the next stated session thereafter, as the Academy may direct. A vacancy in the office of treasurer or home secretary may, however, be filled by appointment of the president of the Academy until the next stated session of the Academy.

SEC. 2. The officers of the Academy, together with six members, to be elected by the Academy at the first stated session in each year, shall constitute a council for the transaction of such business as may be assigned to them by the constitution or the Academy.

SEC. 3. The president of the Academy, or, in case of his absence or inability to act, the vice-president shall preside at the meetings of the Academy and of the council; shall name all committees, except such as are otherwise especially provided for; shall refer investigations required by the Government of the United States to members specially conversant with the subjects, and report thereon to the Academy at its session next ensuing; and, with the council, shall direct the general business of the Academy.

It shall be competent for the president, in special cases, to call in the aid, upon committees, of experts, or men of special attainments, not members of the Academy.

SEC. 4. The foreign and home secretaries shall conduct the correspondence proper to their respective departments, advising with the president and council in cases of doubt, and reporting their action to the Academy at one of the stated sessions in each year.

It shall be the duty of the home secretary to give notice to the members of the place and time of all meetings, of all nominations for membership, and of all proposed amendments to the constitution.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the home secretary.

SEC. 5. The treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the council may require. He shall collect all dues from members, and keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the April session. He shall be the custodian of the corporate seal of the Academy.

ARTICLE III.—OF THE MEETINGS.

SECTION 1. The Academy shall hold one stated session in each year, in the city of Washington, on the third Tuesday in April, and another may be held at such place and time as the council shall determine.

Special sessions of the Academy may be called by order of eight members of the council, at such place and time as may be designated in the call.

Scientific sessions of the Academy may be held at times and places to be designated by a majority of the council.

SEC. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SEC. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business closed.

SEC. 4. The stated meetings of the council shall be held during the stated or special sessions of the Academy. Special meetings may be convened at the call of the president and two members of the council, or of four members of the council.

SEC. 5. No member who has not paid his dues shall take part in the business of the Academy.

ARTICLE IV.—OF ELECTIONS AND RESIGNATIONS.

SECTION 1. All elections shall be by ballot, and each election shall be held separately, unless otherwise ordered by this constitution.

SEC. 2. The time for holding an election for officers shall be fixed by the Academy at least one day before the election is held.

SEC. 3. The six additional members of the council shall be elected on any day after the first of the first stated session in each year, by each voter inscribing six names on his ballot, and those six who have received more votes than any others shall be declared elected. If two or more names have received the lowest number of votes that would elect, additional balloting shall be had for as many members as remain each time to be elected until the number is full.

The term of the members so elected shall commence at the close of the session at which they are elected, and continue until the close of the first stated session in the next year.

SEC. 4. Nominations of members [and foreign associates]* may be made in writing, signed by any five members of the Academy at any stated session, to be voted on at the next stated session held in Washington, and each nomination shall, at the time of election, be accompanied by a written list of the original works of the nominee.

SEC. 5. Elections for membership shall be held in the following manner: Each member may inscribe on a ballot not more than five names of nominees selected from the list. Absent members may send such ballots to the home secretary. From the seven names receiving the highest number of votes in this preference ballot, the members present may proceed to elect new members in the following manner: At each ballot, each member present may vote for not exceeding three persons, and the person receiving the highest number of votes shall be declared elected, provided that he received two-thirds of the votes cast, and that his name appear on not less than twenty ballots; and provided further, that the number of members of the Academy be not already one hundred or over, in which case, to be declared to be elected, he must receive four-fifths of the votes cast, and his name must appear on at least twenty-five ballots.

Should several candidates have the same minimum number of votes on the preference list, the requisite number for completing the list shall be selected from them by a two-thirds vote of the members present.

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* Pending amendment, strike out the words in brackets.

Election of members shall be held only at the regular stated session of each year, held in Washington, and not more than five members shall be elected at that session.

Before, and during elections, a discussion of the merits of nominees will be in order.

The election of members may be suspended at any time by a majority vote of the members present.

SEC. 6. Every member elect shall accept his membership, personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SEC. 7. Foreign associates may be nominated by a committee of five members to be appointed for that purpose by the president, and elected at any stated session by a two-thirds vote of the members present. The election shall be had by each member indicating on a ballot those names for which he votes, and those nominees whose names appear on two-thirds of the ballots shall be declared elected.

SEC. 8. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate secretary to each member on his acceptance of his membership, and to foreign associates on their election.

SEC. 9. Resignations shall be addressed to the president, and acted on by the Academy.

ARTICLE V.—OF SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

SECTION. 1. Communications on scientific subjects shall be read at scientific meetings of the Academy, and papers by any member may be read by the author or by any other member, notice of the same having been previously given to the secretary.

SEC. 2. Any member of the Academy may read a paper from a person who is not a member; and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

Persons who are not members may read papers on invitation of the president with the advice of the council.

SEC. 3. The Academy may provide for the publication, under the direction of the council, of proceedings, memoirs, and reports.

SEC. 4. Propositions for investigations or reports by the Academy shall be submitted to the council for approval; except those requested by the Government of the United States, which shall be acted on by the president, who will, in such cases, report their results to the Government, as soon as obtained, and to the Academy at its next following stated session.

SEC. 5. The advice of the Academy shall be, at all times, at the disposition of the Government, upon any matter of science or art within its scope.

SEC. 6. An annual report to be presented to Congress shall be prepared by the president, and before its presentation submitted by him, first to the council, and afterwards to the Academy at one of the stated sessions.

SEC. 7. Medals and prizes may be established, and the means of bestowing them accepted by the Academy, upon the recommendation of the council, by whom all the necessary arrangements for their establishment and award shall be made.

Bequests and trusts having for their object the advancement of science may also be accepted and administered by the Academy.

ARTICLE VI.—OF THE PROPERTY OF THE ACADEMY.

SECTION 1. All investments shall be made by the treasurer, in the corporate name of the Academy, in stocks of the United States.

SEC. 2. No contract shall be binding upon the Academy which has not been first approved by the council.

SEC. 3. The assessments required for the support of the Academy shall be fixed by the Academy on the recommendation of the council.

ARTICLE VII.—OF ADDITIONS AND AMENDMENTS.

Additions and amendments to the constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change must be given at a stated session, and shall be referred to the council, which may amend the proposition, and shall report thereon to the Academy at the same session. Its report shall be considered by the Academy in committee of the whole for amendment.

The proposition as amended, if adopted in committee of the whole, shall be voted on at the next stated session, and if it receive two-thirds of the votes cast, it shall be declared adopted.

Absent members may send their votes on pending changes in the constitution to the home secretary in writing, and such votes shall be counted as if the member were present.

RULES.

I. In the absence of any officer, a member shall be chosen to perform his duties temporarily, by a pluralty of *viva voce* votes, upon open nomination.

II. The accounts of the treasurer shall be referred to an auditing committee of three members, to be appointed by the president at the meeting at which the accounts are presented; which committee shall report before the close of that session, and shall then be discharged.

The bonds, securities, and other property owned or held in trust by the Academy shall be inspected and verified by a committee to be annually appointed by the president. The report of this committee shall be presented to the Academy at its first stated session in each year, and referred with the accounts to the auditing committee.

III. A committee of arrangements, consisting of five members, shall be appointed by the president for each stated session of the Academy. This committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, &c.; and to arrange the order of reading, and in general, to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be a follows:

1. Chair taken by the president, or, in his absence, by the vice-president.
2. Roll of members called by home secretary.
3. Minutes of the preceding meeting read and approved.
4. Stated business.
5. Reports of president, secretaries, treasurer, and committees.
6. Business from council.
7. Other business.
8. Rough minutes read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless suspended by unanimous consent.

VI. Unless otherwise ordered by the Academy, the scientific meetings shall be convened at noon.

VII. The death of members shall be announced by the president on the last day of any session, when a member shall be selected by the president to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member may be selected by the president, in place of the first, and so on until the duty is performed.

VIII. All discussions as to the claims and qualifications of nominees, at meetings of the Academy, will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the Academy at the time of the discussion.

IX. The secretaries will receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy.

X. Memoirs shall date in the records of the Academy from the date of their presentation to the Academy, and the order of their presentation shall be that in which they were registered, unless changed by consent of the author.

XI. Papers from persons not members, read before the Academy, and intended for publication, shall be referred, at the meeting at which they are read, to a committee of members competent to judge whether the paper is worthy of publication. Such committee shall report to the Academy as early as practicable, and not later than the next stated session.

XII. An annual of the Academy shall be prepared and published by the secretaries.

XIII. The printing of the Academy shall be under the charge of a committee of publication, to consist of the home secretary and four other members to be named by the president with the advice and consent of the council.

XIV. The annual report of the Academy may be accompanied by a memorial to Congress in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XV. The proper secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XVI. The books, apparatus, archives, and other collections of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles so deposited shall be kept by the home secretary, who is authorized to employ a clerk to take charge of them.

XVII. A stamp corresponding to the corporate seal of the Academy shall be kept by the secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels, or other proper marks of similar device, shall be placed upon objects not admitting of the stamp.

XVIII. On the first day of each stated session, immediately after calling the roll of members, a recording secretary shall be elected by a plurality of members present to assist the home secretary in keeping the records of the session.

XIX. It shall be the duty of the committee of arrangements to fix the length of time to be devoted to reading of all papers submitted, and to limit the time to be occupied in their discussion.

XX. Ballots for elections of members may be sent by sealing them up in a blank envelope, and inclosing this in another, across the back of which is written the name of the sender, and which is addressed to the home secretary; such envelopes will be opened only by the tellers.

XXI. Any rule of the Academy may be amended, suspended, or repealed on the written motion of any two members, signed by them and presented at a stated session of the Academy; provided the same shall be approved by a majority of the members present.

XXII. Nominations for membership should state the full name, residence, the official position, and the special scientific studies of the candidate. A form of nomination shall be prepared by the home secretary.

By a resolution adopted January 12, 1864, the president is, *ex officio*, a member of all government committees of the Academy.

APPENDIX C.

ORGANIZATION OF THE ACADEMY.—1883.

	Expiration of term
MARSH, O. C., *President*	April, 1889.
NEWCOMB, S., *Vice-President*	April, 1889.
AGASSIZ, ALEX., *Foreign Secretary*	April, 1886.
HALL, A., *Home Secretary*	April, 1889.
COFFIN, J. H. C., *Treasurer*	April, 1887.

ADDITIONAL MEMBERS OF COUNCIL, 1883-'84.

BAIRD, S. F.
GIBBS, W.
HILGARD, J. E.
MEIGS, M. C.
ROGERS, FAIRMAN.
YOUNG, C. A.

COMMITTEES OF THE ACADEMY.

On Ways and Means to Provide a Fund for the Academy.

ROGERS, FAIRMAN, *Chairman.*
CHANDLER, C. F.
MARSH, O. C.
AGASSIZ, ALEX.
SMITH, J. LAWRENCE.

On Weights, Measures, and Coinage.

BARNARD, F. A. P., *Chairman.*
GIBBS, WOLCOTT.
HILGARD, J. E.
MEIGS, M. C.
NEWCOMB, S.
NEWTON, H. A.
PEIRCE, C. S.
TROWBRIDGE, W. P.

On the Election of Foreign Associates.

AGASSIZ, ALEX., *Chairman.*
DANA, J. D.
GIBBS, W.
HALL, A.
NEWCOMB, S.

On Reserving Public Lands on and near Mount Whitney, California, for Scientific Purposes.

BREWER, W. H.
LANGLEY, S. P.
POWELL, J. W.

On Questions of Meteorological Science and its Applications.

FERRIS, W.
GIBBS, W.
LANGLEY, S. P.
LOOMIS, E.
NEWCOMB, S., *Chairman.*
NEWTON, H. A.
ROOD, O. N.
SCHOTT, C. A.
YOUNG, C. A.

To Report on the Triangulation to Connect the Atlantic and Pacific Coasts.

ABBOT, H. L., *Chairman.*
BARNARD, F. A. P.
MEIGS, M. C.
NEWBERRY, J. S.
NEWCOMB, S.
NEWTON, H. A.
POWELL, J. W.

To Co-operate with the National Board of Health.

MITCHELL, S. WEIR, Philadelphia, Pa.
ENGELMANN, GEORGE, Saint Louis, Mo.
SMITH, J. LAWRENCE, Louisville, Ky.
WOODWARD, J. J., Washington, D. C.
WALKER, F. A., Boston, Mass.
BARKER, GEORGE F., Philadelphia, Pa.
CHANDLER, CHARLES F., New York City.
GIBBS, WOLCOTT, Cambridge, Mass.

On the Investigation of Glucose for the Department of Internal Revenue.

BARKER, G. F., *Chairman.*
BREWER, W. H.
CHANDLER, C. F.
GIBBS, W.
REMSEN, I.

On Publication.

The HOME SECRETARY.
BAIRD, S. F.
COFFIN, J. H. C.
NEWCOMB, S.

On Publications of the Academy.

GILL, T.

On the Total Eclipse of May 6, 1883.

YOUNG, C. A., *Chairman.*
COFFIN, J. H. C.
HALL, A.
HILGARD, J. E.
LANGLEY, S. P.
PEIRCE, C. S.
And by invitation, ROCKWELL, C. H.

Committee to Represent the Academy before Congress.

THE PRESIDENT.
VICE-PRESIDENT.
SECRETARIES.
BAIRD, S. F.
MEIGS, M. C.
POWELL, J. W.

Committee on Printing.

BAIRD, S. F.
COFFIN, J. H. C.
NEWCOMB, S.

On the Relation of the Academy to the Government.

HILGARD, J. E., *Chairman.*
BAIRD, S. F.
COFFIN, J. H. C.
MEIGS, M. C.

On the Henry Draper Medal.

Barker, G. F., *Chairman.*
Newcomb, S.
Gibbs, W.
Wright, A. W.
Young, C. A.

Board of Direction of the Bache Fund.

Dana, J. D.
Hilgard, J. E.
Gibbs, W.

Board of Trustees of the Watson Fund.

Hilgard, J. E.
Newcomb, S.
Coffin, J. H. C.

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, APRIL 21, 1883.

		Date of election.
Abbe, Cleveland	*Washington, D. C.*	1879
Abbot, Henry L., U. S. A	*Whitestone, Long Island, N. Y.*	1872
Allen, J. Asaph	*Cambridge, Mass.*	1876
Agassiz, Alexander	*Cambridge, Mass.*	1866
Baird, Spencer F	*Washington, D. C.*	1864
Barker, George F	*Philadelphia, Pa.*	1876
Barnard, Frederick A. P	*New York City.*	——
Bartlett, William H. C	75 *Locust Hill Ave., Yonkers, N. Y.*	——
Bell, A. Graham	*Washington, D. C.*	1883
Billings, John S., U. S. A	*Washington, D. C.*	1883
Brewer, William H	*New Haven, Conn.*	1880
Brown-Sequard, Charles E	*Paris, France.*	1868
Brush, George J	*New Haven, Conn.*	1868
Chandler, Charles F	*New York City.*	1874
Coffin, John H. C., U. S. N	*Washington, D. C.*	——
Cooke, Josiah P	*Cambridge, Mass.*	1872
Cope, Edward D	2100 *Pine St., Philadelphia, Pa.*	1872
Coues, Elliott	*Washington, D. C.*	1877
Crafts, James M	*Boston, Mass.*	1872
Dalton, J. C	43 *W. Forty-eighth St., New York City.*	1861
Dana, James D	*New Haven, Conn.*	——
Davidson, George	*San Francisco, Cal.*	1874
Eads, James B	*Saint Louis, Mo.*	1872
Farlow, W. G	*Cambridge, Mass.*	1879
Ferrel, William	*Washington, D. C.*	1868
Genth, Frederick A	*W. Philadelphia, Pa.*	1872
Gibbs, Josiah Willard	*New Haven, Conn.*	1879
Gibbs, Wolcott	*Cambridge, Mass.*	——
Gilbert, Grove K	*Washington, D. C.*	1883
Gill, Theodore N	*Washington, D. C.*	1873
Gould, Benjamin A	*Cordoba, Argentine Republic, S. A.*	——
Guyot, Arnold	*Princeton, N. J.*	——
Hall, Asaph, U. S. N	*Washington, D. C.*	1875
Hall, James	*Albany, N. Y.*	——
Hayden, F. V	1803 *Arch St., Philadelphia, Pa.*	1873
Hilgard, Eugene W	*Oakland, Cal.*	1872
Hilgard, Julius E	*Washington, D. C.*	——
Hill, George W	*Washington, D. C.*	1874

		Date of election.
HILL, HENRY B	*Cambridge, Mass.*	1883
HUNT, T. STERRY	*Montreal, Canada.*	1873
HYATT, ALPHEUS	*Soc. of Nat. History, Boston, Mass.*	1875
JACKSON, CHARLES L	*Cambridge, Mass.*	1883
JOHNSON, SAMUEL W	*New Haven, Conn.*	1866
KING, CLARENCE	62 *Cedar St., New York.*	1876
LANGLEY, SAMUEL P	*Observatory, Alleghany, Pa.*	1876
LESLEY, J. PETER	1008 *Clinton St., Philadelphia, Pa.*	——
LOOMIS, ELIAS	*New Haven, Conn.*	1873
LE CONTE, JOHN	*Berkeley, Cal.*	1878
LE CONTE, JOSEPH	*Berkeley, Cal.*	1875
LESQUEREUX, LEO	302 *Fourth St., Columbus, Ohio.*	1874
LOVERING, JOSEPH	*Cambridge, Mass.*	1873
LYMAN, THEODORE	*Brookline, Mass.*	1872
MARSH, O. C	*New Haven, Conn.*	1874
MAYER, ALFRED M	*Hoboken, N. J.*	1872
MEIGS, MONTGOMERY C., U. S. A	*Washington, D. C.*	1865
MITCHELL, S. WEIR	1332 *Walnut St., Philadelphia, Pa.*	1865
MORSE, EDWARD S	*Salem, Mass.*	1876
MORTON, HENRY	*Hoboken, N. J.*	1874
NEWBERRY, J. S	*New York City.*	——
NEWCOMB, SIMON, U. S. N	*Washington, D. C.*	1869
NEWTON, H. A	*New Haven, Conn.*	——
NEWTON, JOHN, U. S. A	*Army Building, New York City.*	1876
OLIVER, JAMES E	*Ithaca, N. Y.*	1872
PACKARD, A. S., Jr	*Providence, R. I.*	1872
PEIRCE, CHARLES S	*U. S. C. Survey, Washington, D. C.*	1877
PETERS, C. H. F	*Clinton, N. Y.*	1876
PICKERING, EDWARD C	*Cambridge, Mass.*	1873
POWELL, JOHN W	*Washington, D. C.*	1880
PUMPELLY, RAPHAEL	*Gibbs Ave., Newport, R. I.*	1872
REMSEN, IRA	*Johns Hopkins University, Baltimore, Md.*	1882
ROGERS, FAIRMAN	202 *W. Rittenhouse Sq., Philadelphia, Pa.*	——
ROGERS, ROBERT E	1104 *Walnut St., Philadelphia, Pa.*	——
ROOD, OGDEN N	*New York City.*	1865
ROWLAND, HENRY A	*Johns Hopkins University, Baltimore, Md.*	1881
RUTHERFURD, LEWIS M	175 *Second Ave., New York City.*	——
SCHOTT, CHARLES A	*Washington, D. C.*	1872
SCUDDER, SAMUEL H	*Cambridge, Mass.*	1877
SELLERS, WILLIAM	1600 *Hamilton St., Philadelphia, Pa.*	1873
SILLIMAN, BENJAMIN	*New Haven, Conn.*	——
TROWBRIDGE, JOHN	*Cambridge, Mass.*	1878
TROWBRIDGE, WILLIAM P	*New York City.*	1872
TRUMBULL, J. H	*Hartford, Conn.*	1872
TUCKERMAN, EDWARD	*Amherst, Mass.*	1868
VERRILL, A. E	*New Haven, Conn.*	1872
WALKER, FRANCIS A	*Boston, Mass.*	1878
WOOD, HORATIO C	1925 *Chestnut St., Philadelphia, Pa.*	1879
WOODWARD, J. J., U. S. A	*Washington, D. C.*	1873
WORTHEN, A. H	*Springfield, Ill.*	1872
WRIGHT, ARTHUR W	*New Haven, Conn.*	1881
YOUNG, CHARLES A	*Princeton, N. J.*	1872

HONORARY MEMBERS.

Engelmann, George	*Saint Louis, Mo.*
Gray, Asa	*Cambridge, Mass.*
Leidy, Joseph	*Philadelphia, Pa.*
Longstreth, Miers F	*Derby, Pa.*

DECEASED MEMBERS.

*Agassiz, Louis	Dec. 14, 1873
*Alexander, J. H	Mar. 2, 1867
Alexander, Stephen	June 25, 1883
*Bache, Alexander Dallas	Feb. 14, 1867
Barnard, J. G	May 14, 1882
*Caswell, Alexis	Jan. 8, 1877
*Chauvenet, William	Dec. 13, 1870
*Clark, Henry James	July 1, 1873
*Coffin, James H	Jan. 6, 1873
Davis, Charles H	Feb. 18, 1877
Draper, Henry	Nov. 20, 1882
Draper, John W	Jan. 4, 1882
*Frazer, John Fries	Oct. 14, 1872
*Gabb, William M	May 30, 1878
*Gilliss, James Melville	Feb. 9, 1865
*Gould, Augustus A	Sept. 15, 1866
*Hadley, James	Aug. 1, 1864
*Haldeman, S. S	Sept. 10, 1880
*Henry, Joseph	May 13, 1878
*Hitchcock, Edward	Feb. 27, 1864
*Holbrook, J. E	Sept. 8, 1871
*Hubbard, J. S	Aug. 16, 1863
Humphreys, A. A., U. S. A	Dec. 28, 1883
*Kirtland, Jared P	Dec. 10, 1877
*Lane, J. Homer	———, 1880
Le Conte, John	Nov. 15, 1883
*Mahan, D. H	Sept. 16, 1871
Marsh, G. P	July 23, 1882
*Meek, F. B	Dec. 21, 1877
Morgan, Lewis H	Dec. 14, 1881
Norton, William A	Sept. 21, 1883
Pourtales, L. F	July 17, 1880
Rodgers, John	May 5, 1882
Rogers, William B	May 30, 1882
*Saxton, Joseph	Oct. 26, 1873
*Silliman, Benjamin, Sr	Nov. 24, 1864
Smith, J. Lawrence	Oct. 12, 1883
Stimpson, William	May 26, 1873
*Strong, Theodore	Feb. 1, 1869
*Sullivant, W. S	April 30, 1873
*Torrey, John	Mar. 10, 1873
*Totten, J. G	Apr. 22, 1864
Warren, G. K	Aug. 8, 1882
Watson, James C	Nov. 23, 1880
*Winlock, Joseph	Jan. 11, 1875
*Wyman, Jeffries	Sept. 4, 1874

***Biographical notices have been presented of those designated by a *.**

FOREIGN ASSOCIATES.

Bunsen, Robert W	*Heidelberg.*
Milne-Edwards, Henry	*Paris.*
Airy, Sir George B	*Greenwich.*
Owen, Richard	*London.*
Burmeister, C. H. C	*Buenos Ayres.*
Struve, Otto von	*Pulkova.*
Adams, J. C	*Cambridge.*
Cayley, Arthur	*Cambridge.*
Clausius, Rudolph	*Bonn.*
Dumas, J. B	*Paris.*
Helmholtz, Baron H. von	*Berlin.*
Kirchoff, G. R	*Berlin.*
Pasteur, Louis	*Paris.*
Stokes, G. G	*Cambridge.*
Sylvester, J. J	*Baltimore.*
Hooker, Sir J. D	*Kew.*
Thomson, Sir William	*Glasgow.*
Auwers, Arthur	*Berlin.*
Bertrand, J. L. F	*Paris.*
Huxley, T. H	*London.*
Virchow, Rudolph von	*Berlin.*
Berthelot, M. P. E	*Paris.*
Boussingault, J. B. J. D	*Paris.*
Chevreul, M. E	*Paris.*
De Candolle, Alphonso	*Geneva.*
Kölliker, Albert von	*Würzburg.*
Oppolzer, Theodore von	*Vienna.*
Richthofen, F. von	*Berlin.*
Würtz, Adolphe	*Paris.*

DECEASED FOREIGN ASSOCIATES.

Sir William Rowan Hamilton.
Karl Ernst von Baer.
Michael Faraday.
L. Elie de Beaumont.
Sir David Brewster.
G. A. A. Plana.
F. W. Argelander.
Joachim Barrande.
Michel Chasles.
Sir Roderick I. Murchison.
Victor Regnault.
H. W. Dove.
C. A. F. Peters.
Justus von Liebig.
Alexander Braun.
Friedrich Wöhler.

APPENDIX D.

LIST OF OFFICIAL REPORTS MADE TO THE GOVERNMENT BY THE NATIONAL ACADEMY OF SCIENCES, AND OF SCIENTIFIC PAPERS PRESENTED TO THE ACADEMY, 1863-1883.

OFFICIAL REPORTS.

1. On the protection of the bottoms of iron vessels. February 4, 1864.
2. On the magnetic deviations in iron ships. February 11, 1864.
3. On an alcoholometer. 1864.
4. On the explosion of the boiler of the United States steamer Chenango. 1864.
5. On the use of aluminium bronze for cent coinage. 1864.
6. On wind and current charts and sailing directions. 1864.
7. On the protection of the national currency against counterfeiting. 1865.
8. On testing the purity of whisky. 1865.
9. On the expansion of steam. 1866.
10. On the preservation of paint on army knapsacks. 1866.
11. On the prevention of counterfeiting. 1866.
12. On proving and gauging distilled spirits. 1866.
13. On the improvement of Greytown Harbor, Nicaragua. 1867.
14. On galvanic action from association of iron and zinc. 1867.
15. On spirit meters. 1868.
16. On the protection of coal mines from explosions by electricity. 1870.
17. On removal of ink from revenue stamps. 1870.
18. On distinguishing calf's-hair goods from woolen goods. 1875.
19. On water-proofing of the fractional currency. 1876.
20. On the surveys of the Territories. 1878.
21. On Demerara sugars. 1878.
22. On proposed changes in the Nautical Almanac. 1878.
23. Committee to co-operate with National Board of Health. 1879–1880.
24. On silk culture in the United States. 1870.
25. On the use of polarized light for determining values of sugars. 1878.
26. On the artificial coloring of sugars designed to simulate a lower grade according to the standard on which duties are levied. 1876–1877.
27. Instructions for the Polaris Expedition. 1873–1877.
28. On building-stone for custom-house, Chicago. 1878.
29. Measurement of velocity of light. 1878.
30. On the preservation of Government collection of Centennial Exhibition. 1876.
31. Magnetic chart of the United States. 1880.
32. Observation of Transit of Venus. 1873–1883.
33. Magnetic observations on the voyage of the Monitor and Monadnock around Cape Horn.
34. Reports on weights, measures, and coinage. 1863–1867.
35. On the construction and verification of the metric standards for the States. 1867.
36. On the introduction of metric scales in Post-Office Department. 1868.
37. International Bureau of Weights and Measures. 1873.

38. On the preservation of the writing of the original Declaration of Independence 1878.
39. Introduction of metric weights and measures in the United States. 1879.
40. On the exploration of the Yellowstone region by General Stanley. 1873.
41. Report on sorghum sugar. 1882.
42. On the separation of methyl from alcohol. 1883.
43. On the total eclipse of May 6, 1883. 1883.
44. Report on glucose. 1883.

SCIENTIFIC PAPERS.

I.—WASHINGTON, JANUARY 4–9, 1864.

1. On individuality among animals, with reference to the question of varieties and species. By LOUIS AGASSIZ.
2. On the elements of the mathematical theory of quality. By BENJAMIN PEIRCE.
3. Discussion of magnetic observations made at Girard College observatory, in the years 1840–'45. Parts IV, V, and VI. Horizontal force; investigation of the eleven-year period; of the solar diurnal variation and annual inequality, and of the influence of the moon. By A. D. BACHE.
4. On the force of fired gunpowder, and the pressure to which heavy guns are actually subjected in firing. By F. A. P. BARNARD.
5. Reduction of the observation of fixed stars made by d'Agelet at Paris during the years 1783–'85, with a catalogue of the corresponding mean places referred to the equinox of 1800. By B. A. GOULD.
6. On the metamorphoses of fishes. By LOUIS AGASSIZ.
7. On the Saturnian system. By BENJAMIN PEIRCE.
8. Notes on the parallelogram of forces, and on virtual velocities. By THEODORE STRONG.
9. On the geographical distribution of fishes, as bearing upon their affinities and systematic classification. By LOUIS AGASSIZ.
10. Discussion of magnetic observations, &c. Parts VII, VIII, and IX. Vertical force; investigation of the eleven-year period, of the solar diurnal variation and annual inequality, and of the influence of the moon. By A. D. BACHE.
11. Description of an anemograph, designed for the University of Mississippi. By F. A. P. BARNARD.
12. On materials of combustion for lamps in light-houses. By JOSEPH HENRY.
13. On photographs of the solar spectrum. By LEWIS M. RUTHERFURD.
14. On tangencies of circles and spheres. By J. G. BARNARD.
15. On observation of the planet Venus, near the times of her inferior conjunction, September 28, 1863, and subsequently. By STEPHEN ALEXANDER.
16. Brief note on the forms of icebergs. By STEPHEN ALEXANDER.

II.—NEW HAVEN, AUGUST 4–6, 1864.

17. Memoir of the late Henry Fits. By LEWIS M. RUTHERFURD.
18. On the distribution of certain important diseases in the United States. By A. A. GOULD.
19. On the integration of differential equations of the first order and higher degrees By THEODORE STRONG.
20. Criticism on the forms of ships. (Presented by Theodore Strong.) By Capt J. COLE.
21. On the light visible on the moon's surface, and that seen adjacent to her edge when the sun is either partially or totally eclipsed. By STEPHEN ALEXANDER

22. On the influence of the hour of the day on the results of barometric measurements of altitudes. By **ARNOLD GUYOT.**
23. On shooting-stars. By **H. A. NEWTON.**
24. A method of determining the errors of a vertical divided circle. (Presented by Benjamin Peirce.) By **SIMON NEWCOMB.**
25. Considerations relative to various phenomena presented by certain comets. By **STEPHEN ALEXANDER.**
26. Memoir of Lieut. E. B. Hunt. By **F. A. P. BARNARD.**

III.—WASHINGTON, JANUARY 3–7, 1865.

27. On a chronograph for measuring the velocity of projectiles. By **J. E. HILGARD.**
28. On the homologies and classification of the cephalopods. By **L. AGASSIZ.**
29. On the geographical distribution of North American birds. By **S. F. BAIRD.**
30. Note on the changes that have taken place in the bar of Charleston Harbor since the sinking of the obstructions in the main channel, as developed by the United States Coast Survey. By **J. E. HILGARD.**
31. On the tables of the moon. By **BENJAMIN PEIRCE.**
32. On the metamorphoses of some malacopterygians. By **L. AGASSIZ.**
33. On chemical classification. By **WOLCOTT GIBBS.**
34. On the dimensions and proportions of American soldiers. By **B. A. GOULD.**
35. On a method of exhibiting certain statistics of hospitals. By **J. L. LE CONTE.**
36. On the special phenomena and present configuration of the State of Maine. By **L. AGASSIZ.**
37. On a regulator for maintaining uniform motion, and an apparatus for recording time observations in type. By **J. E. HILGARD.**
38. On the progress of the geological survey of California. By **J. D. WHITNEY.**
39. On the mineral lands of the United States, and the relations of the Government to their management. By **J. D. WHITNEY.**
40. On the origin and formation of sedimentary rocks. By **J. S. NEWBERRY.**
41. On the origin and distribution of petroleum in the United States. By **J. S. NEWBERRY.**

IV.—NORTHAMPTON, AUGUST 23–26, 1865.

42. The theory of the sling. By **BENJAMIN PEIRCE.**
43. The facoids of the Coal Measures. By **LEO LESQUEREUX.**
44. Letter from. By **L. AGASSIZ.**
45. Observations of the right ascensions of stars within one degree of the north pole. By **B. A. GOULD.**
46. On observations of tides at the island of Tahiti, made by Capt. John Rodgers, of the United States Navy, for the United States Coast Survey. By **J. E. HILGARD.**
47. Discussion of magnetic observations made at Eastport, Me., during the years 1861–1864, by the United States Coast Survey. By **J. E. HILGARD.**
48. On rifled guns. By **W. H. C. BARTLETT.**
49. A new theory of the first principles of the differential calculus. By **THEODORE STRONG.**
50. On the ages of the United States volunteer soldiery, as deduced from the statistical bureau of the Sanitary Commission. By **B. A. GOULD.**
51. On a photometer. By **O. N. ROOD.**
52. On the structure of the moon. By **S. ALEXANDER.**
53. On the systems of mountain upheaval to which the continent of North America owes its present configuration. By **J. D. WHITNEY.**
54. Abstract of geological investigations made in China and Mongolia (communicated by J. D. Whitney). By **RAPHAEL PUMPELLY.**

55. Examination of shells obtained by the sounding-lead in the coast survey of New York and New Jersey, with some nautical hints. By **AUGUSTUS A. GOULD.**
56. On the probable immediate cause of the Glacial Epoch of the Post Tertiary. By **A. GUYOT.**
57 On the Lower Silurian oils of Kentucky and Tennessee.. By **J. S. NEWBERRY.**
58. Suggestions relative to the annular eclipse of the sun in October next. By **S. ALEXANDER.**
59. On certain converging series expressing the ratio of the diameter to the circumference of the circle (communicated by Benjamin Peirce). By **WILLIAM FERREL.**
60. On a tide meter for cold regions (communicated by Benjamin Peirce). By **A. M. BATCHELDER.**

V.—WASHINGTON, JANUARY 24–27, 1866.

61. On the silver reduction process of Nevada, with statistical tables, and metallurgical tables and data. By **B. SILLIMAN.**
62. On a new general method of volumetric analysis. By **WOLCOTT GIBBS.**
63. On sodium amalgam and its application in saving precious metals. By **B. SILLIMAN.**
64. On the limits and character of the vision of American soldiers as deduced by the statistical department of the United States Sanitary Commission. By **B. A. GOULD.**
65. On the primary triangulation of the coast of New England in connection with the United States Coast Survey. By **A. D. BACHE.**
66. On the relation of language to ethnology. By **W. D. WHITNEY.**
67. On certain mineral districts of Arizona. By **B. SILLIMAN.**
68. On California petroleum and the product of its distillation. By **B. SILLIMAN.**
69. Observations on the annular eclipse of October, 1865, made at Lebanon, Ill. By **STEPHEN ALEXANDER.**

VI.—NORTHAMPTON, AUGUST 7–12, 1866.

70. Photometric method. By **OGDEN N. ROOD.**
71. On a normal map of the solar spectrum. By **WOLCOTT GIBBS.**
72. On traces of glaciers under the tropics. By **L. AGASSIZ.**
73. On the secular acceleration of the moon's mean motion. By **JOHN N. STOCKWELL.**
74. On the origin of solar heat. By **BENJAMIN PEIRCE.**
75. On the morphological value and relations of the human hand. By **B. G. WILDER.**
76. On the correlation of gravity and temperature. By **P. E. CHASE.**
77. Grounds of analogy between linguistic science and the physical sciences. By **W. D. WHITNEY.**
78. On the limitation of homologies. By **L. AGASSIZ.**
79. On a new method of optical analysis. By **WOLCOTT GIBBS.**
80. On recent soundings in the Gulf Stream. By **HENRY MITCHELL.**
81. On repeated linear substitutions. By **J. E. OLIVER.**
82. On some points in the geological structure of Southern Minnesota. By **JAMES HALL.**
83. A new theory of planetary motion. By **THEODORE STRONG.**
84. On the linear evaluation of surd forms. By **WILLIAM WATSON.**
85. On the study of young animals, and its bearing upon the progress of palæontology and zoölogy. By **ALEXANDER AGASSIZ.**
86. On the mass of the satellites of Saturn. By **BENJAMIN PEIRCE.**
87. On a remarkable rainbow. By **BENJAMIN PEIRCE.**
88. Investigation in regard to sound in its economical applications. By **JOSEPH HENRY.**

89. On the geographical distribution of fishes in the waters of the Amazon. By LOUIS AGASSIZ.
90. On the stature of American soldiers. By B. A. GOULD.
91. On the influence of the hour of the day on the heights obtained by barometric measurements. By ARNOLD GUYOT.
92. On astronomical photography. By LEWIS M. RUTHERFURD.
93. On the reduction of photographic observations, with a determination of the positions of the Pleiades from photographs by Mr. Rutherfurd. By B. A. GOULD.
94. On a table for facilitating the conversion of longitude and latitude into right ascension and declination. By WILLIAM FERREL.
95. On the *Nephila plumipes*, or silk spider of South Carolina. By B. G. WILDER.

VII.—WASHINGTON, JANUARY 23–27, 1867.

96. On the systematic value of rhynchophorous Coleoptera. By J. L. LE CONTE.
97. On the November meteors. By HUBERT NEWTON.
98. On the total eclipse of the sun of August 7, 1850, in connection with some remarks of the annular eclipse of October, 1865. By STEPHEN ALEXANDER.
99. On some of the phenomena presented by the planet Venus when near her inferior conjunction. By STEPHEN ALEXANDER.
100. On the relative longitude of Europe and America, and the velocity of galvanic signals in the Atlantic cable. By B. A. GOULD.
101. On the principles of the classification of fishes. By LOUIS AGASSIZ.
102. Recent observations on the glacial phenomena of the basin of the Great Lakes. By J. S. NEWBERRY.

VIII.—HARTFORD, CONN., AUGUST 13–17, 1867.

103. A protest against modern nomenclature in zoölogy. By L. AGASSIZ.
104. On the duration of the electric discharge. By O. N. ROOD.
105. On homocercy and heterocercy. By L. AGASSIZ.
106. On new process in analytical chemistry. By WOLCOTT GIBBS.
107. On algebras. By BENJAMIN PEIRCE.
108. On the significance of classes in the animal kingdom. By L. AGASSIZ.
109. Observations in 1865–67 of right ascension of stars observed, by J. Lepaute d'Agelet. By B. A. GOULD.
110. Determination of the proper motions of stars, first observed by J. Lepaute d'Agelet. By B. A. GOULD.
111. On the limitations and conditions of associated linear algebra. By BENJAMIN PEIRCE.
112. On the limitations and conditions of associated linear algebra. By BENJAMIN PEIRCE.
113. The structural character of the selachians. By L. AGASSIZ.
114. Note on a problem of curvature. By THOMAS HILL.
115. Remarks on the geological relations of the mastodon and fossil elephant suggested by the discovery of the Cohoes, N. Y., mastodon. By JAMES HALL.
116. On the precision of the equinoxes and nutation as resulting from the theory of the gyroscope, with remarks explanatory of the deviation of rifled projectiles. By J. G. BARNARD.
117. On single, double, and triple linear associative algebras. By BENJAMIN PEIRCE.
118. On sterility among skates. By LOUIS AGASSIZ.
119. On the fifth pair of nerves and the organ of hearing in skates. By L. AGASSIZ.
120. On periodical ovulation in sharks. By LOUIS AGASSIZ.
121. On quadruple linear associative algebras. By BENJAMIN PEIRCE.
122. Spectroscopic notices. By W. GIBBS.
123. On the value of certain groups in the geological series when studied in their geographical extension. By JAMES HALL.

124. The circulation of blood in selachians. By L. AGASSIZ.
125. On the determination of wave lengths by the method of comparison. By WOLCOTT GIBBS.
126. Parisitic crustacea in the gills of sharks. By L. AGASSIZ.
127. Embryology and affinities of the cylopterus. By L. AGASSIZ.
128. Further remarks explanatory of the deviation of rifled projectiles as resulting from the theory of the gyroscope. By J. G. BARNARD.
129. On a process of integration used in the case of a planet's orbit disturbed by smal forces. By THEODORE STRONG.

IX.—WASHINGTON, JANUARY 22-26, 1868.

130. On the practical character of the usual thermometric scales, and a common substitute for them. By ARNOLD GUYOT.
131. On the use and interpretation of single and double linear associative algebras. By BENJAMIN PEIRCE.
132. On the existence of a great central zone of fracture of the surface of the globe. By ARNOLD GUYOT.
133. Respecting the cosmical theory of the November meteors. By ALEX. TWINING.
134. The history of a week in the life of a young salmon. By L. AGASSIZ.
135. Comparison of the iron meter belonging to the American Philosophical Society, and used as the standard measure of the Coast Survey, with the platinum standard meter of the Conservatoire des Arts et Metiers in Paris, in the summer of 1867. By F. A. P. BARNARD.
136. Some points in the geological development of the continent between the Rio Grande and Arkansas River. By J. L. LE CONTE.
137. On the penetration of sound. By JOSEPH HENRY.
138. On a new reflector as a signal in geodetic observations. By J. E. HILGARD.
139. Remarks upon the condition of the skeleton of the mastodon found at Cohoes, N. Y., and its relations to the geology of the surrounding country. By JAMES HALL.
140. On observations of the zodiacal light. By BENJAMIN PEIRCE.
141. On the fauna of the Gulf of Mexico at great depths. By L. AGASSIZ.
142. Exploration of the coast of Alaska. By GEORGE DAVIDSON.
143. Notes on a treatise on topographical drawing by J. Enthoffer. By J. C. HILGARD.
144. Solution of a particular form of algebraic equation. By BENJAMIN PEIRCE.
145. Note on the velocity of the transmission of perceptions and volitions. By B. A GOULD.
146. Remarks on the buffalo of North America. By LOUIS AGASSIZ.

X.—NORTHAMPTON, MASS., AUGUST 25-29, 1868.

147. On the rainfall of the United States, discussed by Charles A. Schott, Assistant United States Coast Survey, from data collected by the Smithsonian Institute. By JOSEPH HENRY.
148. Remarks on Mr. Airy's reduction of Kirchoff's scale. By WOLCOTT GIBBS.
149. On the origin of bitumens, together with experiments of the formation o asphaltum by S. F. Peckham. By J. D. WHITNEY.
150. On the topography and topographical work west of the 103d meridian. By J. D. WHITNEY.
151. On an invariable meter. By A. C. TWINING.
152. On the tides and tidal currents in an estuary or a canal between two tidal basins. By B. PEIRCE.
153. On the fossil human skull of Calaveras County, California. By J. D. WHITNEY.
154. On deep-sea dredgings in the Gulf Stream. By L. F. POURTALES.
155. On subdivisions of cretaceous and marine tertiary formations in California. By W. M. GABB.

156. On the constitution of uric acid and its derivatives. By WOLCOTT GIBBS.
157. On new methods in analytical chemistry. By WOLCOTT GIBBS. .
158. On the tides and tidal currents of Hell-Gate. By HARRY MITCHEL.
159. On the distribution of the forest vegetation west of the Rocky Mountains. By W. H. BREWER.
160. On the reported occurrence of human bones at Antelope Station, on the Union Pacific Railroad. By O. C. MARSH.
161. On the motions of a freely-suspended pendulum. By J. G. BARNARD.
162. On tides and tidal currents in a harbor. By BENJAMIN PEIRCE.
163. On alphabetic systems as tests of race. By W. D. WHITNEY.
164. On a new borate from Mine Hill, Sussex County, New Jersey. By G. J. BRUSH.
165. On the transportation of the materials of the carboniferous conglomerate. By J. S. NEWBERRY.
166. On the estimation of carbonic acid. By S. W. JOHNSON.
167. On nitrification. By S. W. JOHNSON.
168. On some points in the surface geology of the region west of the Rocky Mountains. By J. D. WHITNEY.
169. On the pendulum and gyroscope as exhibiting the rotation of the earth. By J. G. BARNARD.

XI.—WASHINGTON, APRIL 13–17, 1869.

170. On the age of beaver dams. By ALEXANDER AGASSIZ.
171. On the cooling of the sun and planets. By BENJAMIN PEIRCE.
172. On the most plausible reconstruction of the original Appalachian surface. By J. P. LESLEY.
173. On the bone phosphate beds of South Carolina, their formation, age, and fossils, including the human remains lately discovered. By F. S. HOLMES.
174. On a new meridian and equal altitude instrument used in the Coast Survey. By J. E. HILGARD.
175. On the deep-sea exploration of the Gulf Stream. By BENJAMIN PEIRCE.
176. On tidal researches. By WILLIAM FERREL.
177. On tidal rainfall. By P. E. CHASE.
178. On the products of the action of the alkaline nitrates upon uric acid and its derivatives. By WOLCOTT GIBBS.
179. On inversion in algebra. By BENJAMIN PEIRCE.
180. On a mode of examination of potable waters. By B. F. CRAIG.
181. On the meteorite which fell in Franklin County, Alabama, December 5, 1868. By GEORGE J. BRUSH.
182. On a new member of the chrysolite group. By GEORGE J. BRUSH.
183. On the effects of expansion and contraction in large ice fields, illustrating the formation of anticlinal and synclinal axes in geological formations. By M. C. MEIGS.
184. On international coinage. By S. B. RUGGLES and E. B. ELLIOTT.
185. On the tornado in Iowa and Illinois, June 3, 1860. By W. L. NICHOLSON.
186. On the history and present condition of an investigation of the winds. By JAMES H. COFFIN.
187. On the connection between solar spots, the magnetic declination, and the exhibition of the aurora borealis. By ELIAS LOOMIS.
188. On a certain new method of endiometrical analysis, with examples of analytical work done therewith. By B. SILLIMAN and HENRY WURTZ.
189. On the effects of atmospheric air in reducing the illuminating power of coal gas. By B. SILLIMAN and HENRY WURTZ.
190. On an important modification in the hydrocarbon process for the production of illuminating gas. By B. SILLIMAN.
191. On the physical construction of the sun. By J. H. LANE.
192. On the periodic star in argus. By ELIAS LOOMIS.

XII.—NORTHAMPTON, MASS., AUGUST 31–SEPTEMBER 3, 1869.

193. On the law of distribution of volcanoes and its bearing on the theory of volcanic action. By A. GUYOT.
194. On the correction for temperature and pressure in gas analysis. By WOLCOTT GIBBS.
195. Notice of a worn tooth and tusk of a mastodon indicating glacial action. By JAMES HALL.
196. On the structure of the Rocky Mountains as observed in the southern extension of the Black Hill range, the Sheep Mountain, and the eastern part of the Medicine Bow range. By JAMES HALL.
197. On solar heat and the temperature of the surface of the moon. By J. ERICSSON.
198. On the rate of asimuthal motion of a freely suspended pendulum as corrected for the proper apsidal progression of its orbit. By J. G. BARNARD.
199. On certain ammonia cobalt bases. By WOLCOTT GIBBS.
200. On the total eclipse of August 7, 1869. By B. A. GOULD.
201. On total eclipse of the sun, with observations on the recent eclipse. By STEPHEN ALEXANDER.
202. Notes on the aurora borealis. By W. H. DALL.
203. On the total eclipse of the sun, August 7, 1869. By A. C. TWINING.
204. On accidental colors and their application to the explanation of some phenomena of solar eclipses. By JOSEPH HENRY.
205. On the application of the spectroscope to the analysis of reflected light. By WOLCOTT GIBBS.
206. Contributions to the chemistry of common salt with special reference to our home sources of supply. By CHARLES A. GOESMANN.
207. On constancy of rotation of the earth, incompatible with solar influences. By JOHN ERICSSON.

XIII.—WASHINGTON, APRIL 13–17, 1870.

208. On the measurement of wave-lengths by means of indices of refraction. By WOLCOTT GIBBS.
209. On the coming transits of Venus, and the mode of observing them. By S. NEWCOMB.
210. Meridional arcs measured in connection with the Coast Survey. By J. E. HILGARD.
211. The relations of the four archetypes of structure of the animal kingdom as parts of one life system. By A. GUYOT.
212. Observations on the measurement and iconography of crania. By G. A. OTIS.
213. The Northmen in Greenland. By I. I. HAYES.
214. Considerations on the apparent inequalities of long periods in the moon's mean motion, and on the possible variability of the siderial day. By S. NEWCOMB.
215. On the deviation of compasses in iron-clad ships. By WILLIAM HARKNESS.
216. On the influence of the interior structure of the earth on precession and nutation. By J. G. BARNARD.
217. On the classification of clouds. By ANDRE POEY.
218. On the proposed astronomical observatory in the Argentine Republic. By B. A. GOULD.
219. On the comparison of barometers. By B. F. CRAIG.
220. On certain points in the use of artificial lights in photographing objects; as seen with the microscope. By J. J. WOODWARD.
221. On metric standards. By J. E. HILGARD.
222. On artificial deformation of skulls. By G. A. OTIS.
223. Reduction of photographic observations of Praesepe. By B. A. GOULD.

224. Astronomical photographs. By L. M. RUTHERFURD.
225. On some of the phenomena attending the tornado-thunderstorm of Iowa and Illinois of June 3, 1860. Report made for the Smithsonian Institute. By L. W. NICHOLSON.
226. The basalt of Washington Territory, Oregon, and Idaho. By R. W. RAYMOND.
227. On the lignites of Western America. By J. S. NEWBERRY.
228. Description of the new binocular for the microscope to be used with high powers. By F. A. P. BARNARD.
229. Redemption periods of life annuities and reversions. By E. B. ELLIOTT.
230. On the polarization of the atmosphere. By ANDRE POEY.
231. The classification of mammals. By THEO. GILL.
232. A new form of quarternions. By BENJAMIN PEIRCE.
233. New breeds of hardy silk-worms, which feed on the ailanthus and oaks, and the importance of their introduction into the country, a future industry. By J. Q. A. WARREN.

XIV.—WASHINGTON, APRIL 18–23, 1871.

234. On the waning of the glacial period. By L. AGASSIZ.
235. Explanation of the observed fact that a man's left side walks faster than his right. By WILLIAM FERREL.
236. Additional evidences in regard to the antiquity of man. By J. D. WHITNEY.
237. Optical notices. By WOLCOTT GIBBS.
238. On the discharge of a small Leyden jar. By O. N. ROOD.
239. On the hexatomic compounds of cobalt. By WOLCOTT GIBBS.
240. Determinations of the moon's mass from tide observations. By WILLIAM FERREL.
241. Some account of the progress in the investigation of the laws of winds. By JAMES H. COFFIN.
242. Some phenomena of acoustics. By J. HENRY.
243. On the influence of a covering of snow on climate. By ALEX. WOEIKOF.
244. Systematic zoology and modern nomenclature. By ALEXANDER AGASSIZ.
245. On the formation and motion of glaciers. By J. D. WHITNEY.
246. On certain compounds of iridium. By WOLCOTT GIBBS.
247. Geographical distribution of marine animals. By ALEXANDER AGASSIZ.
248. Non-associative algebra. By BENJAMIN PEIRCE.
249. Observations of the eclipse of the sun, December 22, 1870. By J. C. WATSON.
250. Some remarks on Lambert's formula. By JAMES H. COFFIN.
251. Probabilities in the game of billiards. By BENJAMIN PEIRCE.
252. On the use of the zenith telescope in the observations of the transit of Venus. By ORMOND STONE.

XV.—WASHINGTON, APRIL 16–19, 1872.

253. On evidences of glacial action near Montevideo, South America. By LOUIS AGASSIZ.
254. On the application of photography to the observation of the transit of Venus. By JOSEPH WINLOCK.
255. On observation of solar prominences. By JOSEPH WINLOCK.
256. Remarks on the discovery of two new planets, Nos. 115 and 119. By JAMES C. WATSON.
257. On the progress made in the construction of metric standards for the several States of the Union. By J. E. HILGARD.
258. Biographical memoir of Theodore Strong. By STEPHEN ALEXANDER.

XVI.—CAMBRIDGE, MASS., NOVEMBER 20–22, 1872.

259. The organization of the museum of comparative zoology in Cambridge. By L. AGASSIZ.
260. On three different modes of teething among selachians. By L. AGASSIZ.
261. On the manufacture of gunpowder for great guns, and on increasing the efficiency of small arms by improved ammunition and sights. By M. C. MEIGS.
262. An acoustic pyrometer. By A. M. MAYER.
263. Results of the Coast Survey astronomical expedition to the Rocky Mountains. By CHARLES A. YOUNG.
264. Presentation of an isothermal chart, and of a hypsometric sketch of the United States. By CHARLES A. SCHOTT.
265. Account of the proceedings of the International Metric Commission. By J. E. HILGARD.
266. Development of actiniæ. By ALEX. AGASSIZ.
267. The glacial phenomena of the southern hemisphere compared with those of the northern. By L. AGASSIZ.
268. Affinities of echinoderms and worms. By ALEX. AGASSIZ.
269. On the construction and advantages of a large aneroid barometer. By M. C. MEIGS.
270. Notice of investigations making in California on the reliability of the barometer as a hypsometric instrument. By J. D. WHITNEY.
271. Pedicillariæ of echinoderms. By ALEX. AGASSIZ.
272. On the determination of the relative intensities of sounds, and on the measurement of the powers of various substances to transmit and reflect sonorous vibrations. By A. M. MAYER.
273. Researches on the change of dimensions of iron and steel rods, and of hollow iron cylinders by their magnetization. By A. M. MAYER.
274. Experimental exhibition of the exploration of an acoustic wave-surface. By A. M. MAYER.
275. Analytical notices. By W. GIBBS.
276. Results of recent dredgings on the coast of New England. By A. E. VERRILL.
277. Tidal researches. By W. FERREL.
278. Embryological fragments concerning the volutidæ. By L. AGASSIZ.
279. On the specific identity of some animals along the Atlantic and Pacific shores of America. By L. AGASSIZ.
280. The copulatory organs of the selachians compared with one another and with those of other vertebrates. By L. AGASSIZ.
281. On the changes selachians undergo with age. By L. AGASSIZ.
282. Critical remarks about scientific views entertained upon theoretical grounds. By L. AGASSIZ.
283. Observations on the nature and duration of lightning. By O. N. ROOD.
284. Notice of the progress of the topographical work of the geological survey of California. By J. D. WHITNEY.
285. The 1474 corona line. By C. A. YOUNG.
286. Mathematical reversal and semi-reversal. By BENJAMIN PEIRCE.

XVII.—WASHINGTON, APRIL 15–19, 1873.

287. The determination of singular points of curves and surfaces by the methods of quarternions. By BENJAMIN PEIRCE.
288. On the meteoric iron found in 1871 near Shingle Springs, El Dorado County, California. By BENJAMIN SILLIMAN.
289. Determinations of longitude between Europe and America. By J. E. HILGARD.
290. On the structure and age of the Cincinnati anticlinal. By J. S. NEWBERRY.

On the need of more accurate investigations and tables of the celestial motions. By S. Newcomb.

Experimental and graphic results of distilling certain hydrocarbons by heat with and without the aid of vacuum and steam. By C. F. Chandler and B. Silliman.

The geodesy of the United States Coast Survey. By Benjamin Peirce.

On the general atmospheric circulation. By A. J. Woeikof.

On repeating curves. By H. A. Newton.

Comparison of the spectra of the limb and of the center of the sun made at the Sheffield Scientific School by Charles Hastings. By H. A. Newton.

On the observation of very small stars near the ecliptic, and some peculiarities in two recently discovered minor planets. By J. C. Watson.

On the altitude of Gray's and Torrey's Peaks, in Colorado Territory; some questions connected with the determination of barometric altitudes in the interior of continents. By A. Guyot.

On some experiments made with a slitless spectroscope in 1871 in order to see the whole chromoscope of the sun at once. By Joseph Winlock.

On the stability of the meridian circle of Harvard College. By Joseph Winlock

On the method of illuminating the threads of the reticule of a telescope by the electric spark. By Joseph Winlock.

On observations of the sun made at Harvard College in 1872 with the aid of the Bache fund. By Joseph Winlock.

Report of the progress of a magnetic survey made by the aid of the Bache fund. By J. E. Hilgard.

On certain harmonies of the solar system. By Stephen Alexander.

On the reproduction in progeny of defects produced by injuries in parents. By Charles E. Brown-Sequard.

Silt analysis of soils and clays. By E. W. Hilgard.

On the unity of the system of life in animals, and the true principle of graduation in the various animal types. By A. Guyot.

XVIII.—New York, October 28–31, 1873.

Sound in relation to fog-signals. By Joseph Henry.

Results of explorations of the deeper portions of the Gulf of Maine with the dredge. By A. S. Packard, Jr.

On the constitution of the sun's surface. By C. A. Young.

On the admeasurement of volume. By J. E. Hilgard.

On the determination of the volume of a sphere. By Homer J. Lane.

On the distribution of the thoracic spiracles of insects. By A. S. Packard.

Some results derived from an examination of the United States weather maps. By Elias Loomis.

Circles of deposition in American sedimentary strata. By J. S. Newberry.

On the relations of different classes of vertebrates. By Theodore Gill.

On a new method of analysis of composite sounds, and on experiments elucidating Helmbolt's hypothesis of audition. By A. M. Mayer.

Experimental researches on fluorescence. By Henry Morton.

XIX.—Washington, April 21–25, 1874.

On the classification of the rynchophorous series of coleoptera. By J. L. LeConte.

Combinations of mechanism representing mental processes. By Fairman Rogers.

Suggestions as to the functions of the spiral scale of the cochlea, leading to an hypothesis of the mechanism of audition. By Alfred M. Mayer.

322. Results of a series of experiments on the sets or residual deflections of pine sticks after having been subjected to a transverse stress. By W. A. NORTON.
323. On the pretended localization of the mental and the sensorial faculties of the brain. By CHARLES E. BROWN-SEQUARD.
324. Account of the proceedings of the commission for observing the transit of Venus By SIMON NEWCOMB.
325. The progress made in the survey of the Colorado River of the West and its tributaries, by parties under the direction of the Smithsonian Institution. By J. W. POWELL.
326. On the tides of Tahiti. By WILLIAM FERREL.
327. The law of duration of the residual sonorous sensation. By ALFRED M. MAYER.
328. On metamerism in inorganic chemistry. By W. GIBBS.
329. An outline of the history and operations of the United States Geological Survey of the Territories, with some account of its results. By F. V. HAYDEN.
330. On a small correction of the velocity of light, as deduced from experiments. By STEPHEN ALEXANDER.
331. Mineralogical notes. By B. SILLIMAN.
332. Experiments on the reflection of sound from flames and heated gases. By A. M. MAYER.
333. On the laws of cyclones. By WILLIAM FERREL.
334. The history of Smith Sound, in a geographical and geological point of view, and some other general results of the Polaris expedition. By E. BESSELS.
335. Some results of an examination of the United States weather maps for the years 1872 and 1873. By ELIAS LOOMIS.
336. On the so-called land plants of the Lower Silurian of Ohio. By J. S. NEWBERRY.
337. Report on the great telescope of the United States Naval Observatory. By SIMON NEWCOMB.
338. The geographical distribution of the lignite group of the Southwest, with some remarks in regard to its age. By F. V. HAYDEN.
339. On certain phenomena sometimes presented by three of the satellites of Jupiter. By STEPHEN ALEXANDER.
340. A criticism on the contractional hypothesis of the earth's surface-change. By C. E. DUTTON.
341. On the polarization of the zodiacal light. By A. W. WRIGHT.
342. On some points in Mallet's theory of vulcanicity. By E. W. HILGARD.
343. On the zodiacal light. By STEPHEN ALEXANDER.
344. A new set of Bernouilli's numbers. By J. D. WARREN.

XX.—PHILADELPHIA, NOVEMBER 3–6, 1874.

345. Additional results derived from an examination of the United States weather reports. By ELIAS LOOMIS.
346. A new method of investigating the composite nature of the electric discharge. By A. M. MAYER.
347. On the specific gravity of the waters of the Gulf of Maine. By A. S. PACKARD, Jr.
348. On ancient ruins in Southwestern Colorado. By F. V. HAYDEN.
349. Some examples of the decomposition of rocks. By T. STERRY HUNT.
350. On an undescribed organ in Limulus, supposed to be venal in its nature. By A. S. PACKARD.
351. New discussion of the secular change of the magnetic declination in the United States and adjacent countries in North America. By CHARLES A. SCHOTT.
352. On a method of measuring minute variations in atmospheric pressure. By A. M. MAYER.
353. On the change in dimension of hollow iron cylinders and solid iron rods on their magnetization. By A. M. MAYER.

354. On the horizontal pendulum as arranged for purposes of physical investigation. By OGDEN N. ROOD.
355. On the effect of magnetism on the thickness of soft iron bars. By OGDEN N. ROOD.
356. On atmospheric air as engaged with sound. By JOSEPH HENRY.
357. On summary of work done by the United States Geological Survey of the Territories during the season of 1874. By F. V. HAYDEN.
358. On a method of separating ammonia and its compounds from gaseous mixtures. By B. SILLIMAN.
359. On an instance of total replacement of porphyry matrix by metallic copper. By RAPHAEL PUMPELLY.
360. An additional character serving to define the rhynchophorous series of coleoptera. By J. L. LE CONTE.
361. On the use of a mineral poison for the protection of agriculture. By J. L. LE CONTE.
362. Notes on Grant's difference engine. By F. ROGERS.
363. Observations on the Newport conglomerate. By W. B. ROGERS.
364. Simple mode of producing electricity for lecture-room purposes. By R. E. ROGERS.
365. Remarks in regard to the age of the lignitic group of Colorado. By F. V. HAYDEN.
366. On the value of paleontological evidence in determination of strata. By THEODORE GILL.
367. Description of a balance for determining specific gravities without calculation. By F. A. P. BARNARD.

XXI.—WASHINGTON, APRIL 20–23, 1875.

368. Results derived from an examination of the United States weather maps for 1872, 1873, and 1874. By ELIAS LOOMIS.
369. Notes on observation of the transit of Venus. By G. DAVIDSON.
370. On an improvement of the present civil or Gregorian calendar. By J. P. BRADLEY.
371. Results of experiments on the set of rectangular bars of wood, iron, and steel, resulting from a transverse stress. By W. A. NORTON.
372. Note on Goldschmid's aneroid barometer. By J. E. HILGARD.
373. Sketch of progress of second geological survey of Pennsylvania. By J. P. LESLEY.
374. On the orography of the Catskill group of mountains. By A. GUYOT,
375. Report of the committee on weights, measures, and coinage. By F. A. P. BARNARD.
376. On the observations of contacts in transits of Venus and Mercury. By S. NEWCOMB.
377. New formula for the deflections of rectangular bars or beams, resting on supports and subjected to a transverse stress. By W. A. NORTON.
378. Size of the brain of extinct mammals. By O. C. MARSH.
379. Account of researches in solar physics made at the Alleghany Observatory during the past four years. By S. P. LANGLEY.
380. Use of the stereoscope in the study of solid geometry. By JAMES D. WARNER.
381. On the interpolation of a change of sign by passage through infinity of a mathematical function expressive of a physical phenomenon; a curious particular case in the theory of tides. By J. G. BARNARD.
382. On the discussion of the laws of atmospheric circulation, by Prof. James H. Coffin (now deceased). By SELDEN J. COFFIN.
383. On the influence of arsenical compounds upon vegetation. By WM. MCMARTIN.
384. Preliminary account of results of a magnetic survey made at the charge of the Bache fund. By J. E. HILGARD.
385. On the relations of some of our ancient fossil fishes to living forms. By J. S. NEWBERRY.
386. On areas of cold. By A. WOEIKOF.

XXII.—PHILADELPHIA, NOVEMBER 2–5, 1875.

387. On the evidence of horizontal crushing in the formation of the Coast Range of California. By JOSEPH LE CONTE.
388. Contributions to meteorology. By ELIAS LOOMIS.
389. On the composition of schorlomite. By GEORGE A. KOENIG.
390. Sound in its applications to fog-signals. By JOSEPH HENRY.
391. Table of the sedimentary group of the plateaus. By J. W. POWELL.
392. Second notice of Grant's difference engine. By FAIRMAN ROGERS.
393. A new and simple form of compensating pendulum. By J. LAWRENCE SMITH.
394. A confirmation of my theory of the zodiacal light. By STEPHEN ALEXANDER.
395. Exposition of several very peculiar astronomical phenomena. By STEPHEN ALEXANDER.
396. Influence of marine life and currents in the formation of metalliferous deposits. By RAPHAEL PUMPELLY.
397. A soluble crystalline product from the graphite of meteoric iron. By J. LAWRENCE SMITH.
398. A notice of the modern system of chemical terminology. By R. E. ROGERS.
399. On the steam geysers of California, and on the chemistry of the mines of the Comstock Lode. By R. E. ROGERS.

XXIII.—WASHINGTON, APRIL 18–22, 1876.

400. On the precise determination of the number of vibrations of tuning-forks, and on the effect of temperature and of amplitude on the same. By A. M. MAYER.
401. On the theory of simultaneous ignition of many mines. By H. L. ABBOT.
402. On the theory of magic squares. By F. A. P. BARNARD.
403. Contributions to meteorology. By ELIAS LOOMIS.
404. On the sensations produced by concurrent and rapidly succeeding sounds. By A. M. MAYER.
405. On maxima and minima in algebra, by the late General D. P. Woodbury, with a biographical notice of the author. By J. G. BARNARD.
406. The character of the Eocene fauna of New Mexico. By E. D. COPE.
407. On the history of the problem of tangencies. By BENJAMIN ALVORD.
408. On the geological evidences on the question of the cause of the cold of the ice period. By J. S. NEWBERRY.
409. Biographical memoir of Joseph Winlock. By J. LOVERING.
410. On a method of exploring the acoustic condition of the atmosphere leading to determining the direction of a source of sound. By A. M. MAYER.
411. On the geological and physical structure of the Black Hills. By HENRY NEWTON.
412. On the imperfection of the present system of chemical nomenclature. By R. E. ROGERS.
413. The age of mountains as determined by degradation. By J. W. POWELL.
414. On the progress of the magnetic survey of the United States at the charge of the Bache fund of the Academy. By J. E. HILGARD.
415. Results of experiments on contact resistance. By WILLIAM A. NORTON.
416. A conjectural restoration of the pueblo of the mound-builders. By L. H. MORGAN.
417. On the geology of petroleum. By J. S. NEWBERRY.

XXIV.—PHILADELPHIA, OCTOBER 17–19, 1876.

418. Contributions to meteorology. By ELIAS LOOMIS.
419. Upon the direct comparison of solar radiation with that of the Bessemer furnace and upon the law of Du Long and Petit. By S. P. LANGLEY.
420. On the affinities of hypocephalus. By J. L. LE CONTE.

421. On a change in the relative length of the British bronze and iron standard yards in the United States office of weights and measures. By J. E. HILGARD.
422. On sounds in relation to fog-signals. By JOSEPH HENRY.
423. The results of an investigation upon the transformation of Planorbis multiformis. By ALPHEUS HYATT.
424. On the transmission of the shock of the explosion at Hell Gate. By H. L. ABBOT.
425. On the geological structure and topographical aspects of the Catskill Mountains. By JAMES HALL.
426. On the physical structure and altitudes of the southern group of the Catskill Mountains. By A. GUYOT.
427. On the force involved in Crooke's radiometer. By O. N. ROOD.
428. On a new method of studying reflection of sound-waves. By O. N. ROOD.
429. On a property of the retina first observed by Tate. By O. N. ROOD.
430. On a series of molecular changes in the basaltic rocks of Lake Superior. By R. PUMPELLY.
431. On the power of certain substances to abstract salts from their solution in water by filtration through them. By R. E. ROGERS.
432. On the compensation of a pendulum heretofore described. By J. LAWRENCE SMITH.

XXV.—WASHINGTON, APRIL 17-20, 1877.

433. On a new measuring instrument, the Vernier microscope. By A. M. MAYER.
434. On systematic errors in star declinations. By E. C. PICKERING and W. A. ROGERS.
435. On the young stages of some osseous fishes. By ALEXANDER AGASSIZ.
436. On critical periods in the history of the earth, and their relations to evolution, and on the quaternary at such a period. By JOSEPH LE CONTE.
437. On the progressive motion of storms. By WILLIAM FERREL.
438. Contributions to meteorology. By E. LOOMIS.
439. Improved method of obtaining metallic spectra. By G. F. BARKER.
440. On the effect produced by mixing white with colored light. By O. N. ROOD.
441. On Newton's use of the term indigo, with reference to a color of the spectrum. By O. N. ROOD.
442. Internal structure of the earth as affecting the phenomena of precession and nutation: supplementary to article under this head read before the Academy and published in Vol. XIX, Smithsonian Contributions. By J. G. BARNARD.
443. On a method of solar spectrum analysis. By S. P. LANGLEY.
444. On complex inorganic acids. By WOLCOTT GIBBS.
445. Micrometer-level and topographical camera. By E. C. PICKERING.
446. On the determination of the coefficient of expansion of solids. By A. M. MAYER.
447. The results of deep-sea dredgings. By ALEXANDER AGASSIZ.
448. Description of a detached gravity escapement. By C. A. YOUNG.
449. On the laws ruling the vibrations of tuning-forks. By A. M. MAYER.
450. On the structure of the "Henry" Mountains. By G. K. GILBERT.
451. On some remarkable facts in the distribution of magnetism in very long (60 inches) magnets. By A. M. MAYER.
452. Remarks on some artesian wells along the line of the Union Pacific Railroad, in Wyoming Territory. By F. V. HAYDEN.
453. On the structure of the crystalline lens and its relation to periscopism. By JOSEPH LE CONTE.
454. Remarks on the apparent secular acceleration of the mean motion of the moon, as derived from the observations of ancient eclipses. By SIMON NEWCOMB.
455. Researches in lunar theory. By GEO. W. HILL.
456. On the public domain. By J. W. POWELL.

XXVI.—NEW YORK, OCTOBER 23–25, 1877.

457. On the laws of extreme distances in the solar system. By **STEPHEN ALEXANDER.**
458. Velocity of transmission of shocks caused by the explosion of gunpowder and of nitro-glycerine compounds through the earth's crust. By **HENRY L. ABBOT.**
459. On the morphology of the antlers of the Cervidæ. By **THEODORE GILL.**
460. On a new and simple method of determining the number of vibrations of sonorous bodies. By **A. M. MAYER.**
461. On a construction for the study of the contrast of colors. By **O. N. ROOD.**
462. Whence came the inner satellite of Mars. By **STEPHEN ALEXANDER.**
463. On the photometric comparisons of light of different colors. By **O. N. ROOD.**
464. Contributions to meteorology (eighth paper). By **ELIAS LOOMIS.**
465. On abnormal phenomena of sound in relation to fog signals, on behalf of the United States Light-House Board. By **JOSEPH HENRY.**
466. On the development of flounders. By **ALEXANDER AGASSIZ.**
467. On the luminous band which seems to encircle the moon during a partial solar eclipse. By **STEPHEN ALEXANDER.**
468. Note on the hydraulic limestone and associated strata at the falls of the Ohio. By **JAMES HALL.**
469. On some gigantic Dinosaurian reptiles from the wealden of the Rocky Mountains. By **O. C. MARSH.**
470. On comets. By **H. A. NEWTON.**
471. On the inclinations in a direction retrograde to the shadow of the planets. By **STEPHEN ALEXANDER.**
472. On a method of studying the velocity of sound in wood. By **Dr. M. C. IHLSENG.**
473. On some new fossil fishes from Ohio and Indiana. By **J. S. NEWBERRY.**
474. On the geological age of the western lignites. By **J. S. NEWBERRY.**
475. Remarks on the analyses of columbate, and on the native iron and basalt of Greenland, with exhibition of specimens showing the occurrence of sulphuret of chrome in meteoric iron. By **J. LAWRENCE SMITH.**
476. On the air-sacs of locusts. By **A. S. PACKARD, Jr.** (Communicated by Alexander Agassiz.)
477. On the glycogenic function of the liver, and its relation to vital force and vital heat. By **JOSEPH LE CONTE.**
478. American cretaceous birds. By **O. C. MARSH.**
479. Biographical memoir of Louis Agassiz; 1st part. Relating to his life and work in Europe. By **A. GUYOT.**

XXVII.—WASHINGTON, APRIL 16–19, 1878.

480. Formation and structure of Alacrane Reef, on the Yucatan bank. By **A. AGASSIZ.**
481. The theory of water-spouts. By **WM. FERREL.**
482. Report on the orbits of the satellites of Mars. By **A. HALL.**
483. The relation of loess and drift to secular disintegration. By **R. PUMPELLY.**
484. The characteristic invertebrate forms of the central zoo-geographical province of the United States. By **A. S. PACKARD, Jr.**
485. On an optical ocean salinometer. By **J. E. HILGARD.**
486. Preliminary report on deep-sea dredgings of the United States Coast Survey, steamer Blake, during the past winter, in the Gulf of Mexico and in the Gulf Stream. By **A. AGASSIZ.**
487. Abrasions on the northwest coast of America. By **G. DAVIDSON.**
488. On the law of Boyle and Mariotte. By **W. GIBBS.**
489. Abstract of memoir on the intersection of circles and the intersection of spheres. By **B. ALVORD.**

490. Biographical memoir of Louis Agassiz; 2d part. Relating to his life and work in America. By A. GUYOT.
491. Biographical memoir of Jeffries Wyman. By A. S. PACKARD, Jr.
492. Plan for measuring the velocity of light. By S. NEWCOMB.
493. On the force of effective molecular action. By W. A. NORTON.
494. On the value of the results obtained for the solar parallax from the English telescopic observations. By C. H. F. PETERS.
495. On the vertebrate fauna of the Permian period of the United States. By E. D. COPE.
496. Report of progress on the subject of oxygen in the sun. By H. DRAPER.
497. Photometric comparison of the components of close double stars. By E. C. PICKERING.
498. On the duplication of geographical names. By F. V. HAYDEN.
499. Characteristics of some of the lower spectral lines. By S. P. LANGLEY.
500. A new element of the cerium group. By J. L. SMITH.
501. On the primary zoo-geographical divisions of the globe, and their relations. By T. N. GILL.
502. Mr. Wallace and Mr. Allen on geographical distribution, with special reference to the alleged distinctness of the nearctic region. By E. COUES.
503. On the laws governing the movements of the Rocky Mountain locusts. By C. V. RILEY.
504. On the structure and origin of mountains, with special reference to recent objections to the contractional theory. By JOSEPH LE CONTE.
505. Photometric measures of certain faint stars and planets. By E. C. PICKERING.
506. Contributions to meteorology. By E. LOOMIS.
507. Recent displacements in Utah. By G. K. GILBERT.
508. Supplementary notice on the paper "Whence came the inner satellite of Mars," read at the October session, 1877. By S. ALEXANDER.

XXVIII.—NEW YORK, NOVEMBER 5–8, 1878.

Title of papers read at the November session, 1878.

509. On the solar eclipse of July 29, 1878. By HENRY DRAPER.
510. The early types of insects. By S. H. SCUDDER.
511. On the acceleration of gravity at initial stations. By C. S. PEIRCE.
512. The inapplicability of the old theory of turbine water-wheels to the new constructions of Boyden and Francis. By W. P. TROWBRIDGE.
513. The embryology of the gar-pike. By A. AGASSIZ.
514. On arrangement of a zoological marine laboratory at Newport. By A. AGASSIZ.
515. On the value of photography in the study of instantaneous phenomena, illustrated by photographs taken at successive stages of torpedo explosions. By H. L ABBOT.
516. On the eleventh axiom of Euclid, with a proposed demonstration of the same. By S. ALEXANDER.
517. A biographical memoir of Prof. Dennis Hart Mahan. By H. L. ABBOT.
518. A continuation of a paper presented at the April meeting on the "Intersection of circles and the intersection of spheres." By B. ALVORD.
519. Contribution to meteorology; storms of the Atlantic Ocean. By E. LOOMIS.
520. On the instruments of precision at the Paris Exposition, &c. By G. DAVIDSON.
521. On some remains of new fossil fishes and their relation to living forms. By J. S. NEWBERRY.
522. On the quantitive analysis of white light. By O. N. ROOD.
523. On measures of the diameter of Mercury by a new method, made at the transit of May 6, 1878. By C. A. YOUNG.

524. A recapitulation of some of the author's views on the origin of the forms and the present state of many of the clusters of stars and of several of the nebulæ, source of solar heat, and drift of the stars. By S. ALEXANDER.
525. On some mooted points in American geology. By J. S. NEWBERRY.
526. On Hering's theory of color. By O. N. ROOD.
527. On the characters of the theromorphous reptilia and stegocephalous batrachia. By E. D. COPE.
528. Brief notice of the total solar eclipse of January 11, 1880. By S. ALEXANDER.
529. Some remarks on an investigation of the laws of heredity, undertaken by the board of health of Massachusetts. By A. HYATT.
530. On certain modifications of the Schehallien experiment, and of the Cavendish experiment. By S. ALEXANDER.

XXIX—WASHINGTON, APRIL 15–18, 1879.

531. Ghosts in the diffraction spectra. By C. S. PEIRCE.
532. Comparisons of the meter with wave lengths. By C. S. PEIRCE.
533. On the relations of neuralgic pains to storms and the earth's magnetism. By S. WEIR MITCHELL.
534. Confirmations by spectrum photographs of the discovery of oxygen in the sun. By HENRY DRAPER.
535. On vowel theories, considered in the light of recent experiments with the phonograph and phonautograph. By A. GRAHAM BELL.
536. The Palæozoic cockroaches. By S. H. SCUDDER.
537. On the eclipses of Jupiter's satellites. By E. C. PICKERING.
538. On a new form of heliostat. By ALFRED M. MAYER.
539. On the extinct species of the rhinoceros and allied forms of North America. By E. D. COPE.
540. On the errors of pendulum experiments, and on the method of swinging pendulums proposed by Mr. Faye. By C. S. PEIRCE.
541. The loess of the Mississippi, and the Æolian hypothesis. By E. W. HILGARD.
542. The extinct volcanoes about Lake Mono, and their relation to our glacial drift. By JOSEPH LEE CONTE.
543. Report on the progress of the International Bureau of Weights and Measures. By J. E. HILGARD.
544. On the stability and instability of drainage lines. By G. K. GILBERT.
545. On a new polariscopic method for the detection and estimation of dextro-glucose in the presence of cane and invested sugars. By CHARLES F. CHANDLER.
546. On the ignition of high-tension fuses. By HENRY L. ABBOT.
547. On the hibernations and migrations of *Aletia argilacea* (the parent of the cotton worm). By C. V. RILEY.
548. Report on dredgings in the Caribbean Sea by the Coast Survey steamer Blake, Commander John R. Bartlett, United States Navy. By ALEXANDER AGASSIZ.
549. On two new forms of micrometers. By E. C. PICKERING.
550. On the physical hydrography of the Gulf of Maine. By HENRY MITCHELL.
551. The winds on Mount Washington compared with the winds near the level of the sea. By ELIAS LOOMIS.
552. On a mineral locality in Fairfield County, Connecticut. By G. J. BRUSH.
553. On the great silver deposits recently discovered in Colorado, Utah, and Nevada. By J. S. NEWBERRY.
554. On the recurrence of solar eclipses. By SIMON NEWCOMB.
555. On the influence of Jupiter upon bodies passing near that planet. By H. A. NEWTON.
556. On the projections of the sphere which preserve the angles. By C. S. PEIRCE.
557. Report of the Committee on Weights, Measures, and Coinage. By F. A. P. BARNARD.

558. An account of geodetic arcs determined by the Coast Survey in relation to the figure of the earth. By J. E. HILGARD.
559. A biographical memoir of the late Dr. Theodore Strong. By Justice J. P. BRADLEY.
560. A biographical memoir of the late Dr. Jared P. Kirtland. By J. S. NEWBERRY.
561. On two more diazo colors from coal-tar. (Read by title only.) By C. F. CHANDLER.

XXX.—NEW YORK, OCTOBER 25–30, 1879.

562. On photographing spectra of the stars. By HENRY DRAPER.
563. Spectroscopic notes. By C. A. YOUNG.
564. Original researches, reported in the second volume of the Medical and Surgical History of the War of the Rebellion. By J. J. WOODWARD.
565. Some observations on the structure of the human brain. By J. C. DALTON.
566. Some remarks on a new map of the Catskill Mountains, and on the topographical relations of that mountain group to the adjacent regions of the Appalachian system. By A. GUYOT.
567. Brief comments on the nebular hypothesis of La Place. By S. ALEXANDER.
568. On some new and remarkable forms of crinoidea from the lower Helderberg formation. By J. HALL.
569. Notes on the Lycoperditis vanuxemi and allied forms. By J. HALL.
570. Mean pressure of the atmosphere over the United States at different seasons of the year. By E. LOOMIS.
571. The satellites of Mars in 1879. By A. HALL.
572. Questions as to a very direct and simple method of ascertaining the ellipticity of the terrestrial spheroid. By S. ALEXANDER.
573. The completion of the theory of parallel straight lines. By S. ALEXANDER.
574. Old river beds of California. By JOSEPH LE CONTE.
575. On our memory for color and luminosity. By O. N. ROOD.
576. On absorption of the solar atmosphere. By S. P. LANGLEY.
577. On the glycogonic function of the liver. By JOSEPH LE CONTE.
578. On Arago's experiment showing the magnetism of a conductor. By G. F. BARKER.
579. On the vegetation of the Atlantic coast of North America in the cretaceous age. By J. S. NEWBERRY.
580. On some interesting deposits of gold and silver ores in Utah and Colorado. By J. S. NEWBERRY.
581. On mocandrum and other earths recently announced as occurring in gadolinite, samarkite, &c. By J. LEE SMITH.

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582. Binocular vision; laws of ocular motion. By JOSEPH LE CONTE.
583. On hollow water-spouts and sand-spouts. By WILLIAM FERREL.
584. On the structure of the vertebrata of the Permian period. By E. D. COPE.
585. On the perforations in the squamosal bone of the mammalia. By E. D. COPE.
586. Contributions to meteorology; on sudden changes of temperature at stations near the Rocky Mountains. By E. LOOMIS.
587. The sea urchins of the Challenger expedition. By A. AGASSIZ.
588. On the structure of the brain of Limulus Polyphemus. By A. S. PACKARD.
589. Conclusion of the investigations of the laws of ruling the vibrations of tuning-forks. By A. M. MAYER.
590. On the size of the brains of extinct animals. By O. C. MARSH.
591. On new complex inorganic acids. By W. GIBBS.
592. On the use of the electric telegraph during total eclipses, applied to the search for intra-mercurial planets. By D. P. TODD.

593. On the telegraphic determinations of longitude by the United States Hydrographic Office. By F. H. GREEN.
594. On the taconic system in geology. By T. S. HUNT.
595. On an instrument for measuring radiant heat. By S. P. LANGLEY.
596. On the composition of colors. By S. P. LANGLEY.
597. On the nebula of Orion. By E. S. HOLDEN.
598. On the distribution of the Zonopis conchifera. By T. N. GILL.
599. On the solar corona. By WILLIAM HARKNESS.
600. On an early race of man in Japan. By E. S. NORSE.
601. Revision of atomic weight of antimony. By J. P. COOKE.
602. Cloud-bursts. By WILLIAM FERREL.
603. On the effects of vibrations transmitted by railroad trains on observations in fixed observatories. By H. H. PAUL.
604. On the modifications suffered by light on passing through a very narrow slit. By A. A. MICHELSON.
605. Some remarks on the supposed nature of the sun's corona. By J. L. SMITH.
606. On a supposed new meteoric silicate. By J. L. SMITH.
607. On some modern developments bearing upon the nebular hypothesis and other matters connected therewith, as well as on some previous changes and miscellaneous notices. By S. ALEXANDER.

XXXII.—NEW YORK, NOVEMBER 16–19, 1880.

608. Report on the dredging cruise of the United States steamer Blake, Commander Bartlett, during the summer of 1880. By ALEXANDER AGASSIZ.
609. On the intimate structure of certain mineral veins. By BENJAMIN SILLIMAN.
610. Notes on the relations of the Oneonta and Montrose sandstones with the sandstones of the Catskill Mountains. By JAMES HALL.
611. On the new general method of analysis. By WOLCOTT GIBBS.
612. On some recent experiments in determining the electro-motive force of the Brush dynamo-electric machine. By HENRY MORTON.
613. Measurement of new form of electric lamps operating by incandescence. By HENRY MORTON.
614. On the Phenacodontidæ. By E. D. COPE.
615. On the Nimravidæ and Canidæ of the Miocene period. By E. D. COPE.
616. On the basin of the Gulf of Mexico. By J. E. HILGARD.
617. On the origin of the coral of reefs of the Yucatan and Florida banks. By ALEXANDER AGASSIZ.
618. Observations on ice and icebergs in the Polar regions. (By invitation of the Academy.) By Lieut. F. SCHWATKA, U. S. A.
619. On the duration of the Arctic winter. (By invitation of the Academy.) By Lieut. F. SCHWATKA, U. S. A.
620. Mineralogical notes. By BENJAMIN SILLIMAN.
621. The relationship of the Carboniferous to living and extinct Myriapods. By SAMUEL H. SCUDDER.
622. On measurement of radiant energy. By S. P. LANGLEY.
623. On the bolometer. By S. P. LANGLEY.
624. Causes which determine the progressive movements of storms. By ELIAS LOOMIS.
625. On the antimony mines of Southern Utah. By J. S. NEWBERRY.
626. On the conglomerate ore deposits of the United States and Mexico. By J. S. NEWBERRY.
627. On an improvement in the Sprengel air-pump. By O. N. ROOD.
628. On the deposits of crystalline ores in Utah. By J. S. NEWBERRY.
629. On the origin of anthracite. By T. STERRY HUNT.
630. On the star list of Abul Hassan. By C. H. F. PETERS.
631. On photographing the nebula in Orion. By HENRY DRAPER.

632. On condensers for currents of high potential. By GEORGE F. BARKER.
633. On Sigsbee's gravitating trap. By ALEXANDER AGASSIZ.
634. On the ellipticity of the earth as deduced from pendulum experiments. By CHARLES S. PEIRCE.
635. Dimensions of the brain and spinal cord in some extinct animals. By O. C. MARSH.

XXXIII.—WASHINGTON, APRIL 19–22, 1881.

636. On the domain of physiology. By T. STERRY HUNT.
637. The compass plant of the western prairies. (By invitation of the Academy.) By B. ALVORD.
638. The solar constant. By S. P. LANGLEY.
639. The color of the sun. By S. P. LANGLEY.
640. On mountain observations. By S. P. LANGLEY.
641. On the relations of soils to health. By R. PUMPELLY.
642. Reduction to sea level of barometric observations made at elevated stations. By ELIAS LOOMIS.
643. On electric light photometry. By GEORGE F. BARKER.
644. On the condenser method of measuring high tension currents. By GEORGE F. BARKER.
645. On the relations between strains and impacts and the structure of the feet of mammalia. By E. D. COPE.
646. On the progress of pendulum work. By C. S. PEIRCE.
647. On the carbon lamp fiber in the thermo-balance. By GEORGE F. BARKER.
648. Upon the production of sound by radiant energy. By A. GRAHAM BELL.
649. On the later tertiary of the Gulf of Mexico. By E. W. HILGARD.
650. On the utilization of the sun's rays in heating and ventilating. By EDWARD S. MORSE.
651. Recent researches in the vicinity of Bering's Strait, an account of the land ice of Kotzebue Sound and the Arctic coast. By W. H. DALL.
652. Recent researches in the vicinity of Bering's Strait; (II) additions to our knowledge of the currents and temperature of the ocean in the vicinity of Bering's Strait. By W. H. DALL.
653. Results just obtained with regard to the molecular weight of hydro-fluoric acid. By J. W. MALLET.
654. A method for finding the proximities of the orbits of minor planets. By C. H. F. PETERS.
655. On incandescent lights. By GEORGE F. BARKER.
656. On the auriferous gravels of California. By T. STERRY HUNT.
657. Biographical memoir of Louis F. Pourtales. By A. AGASSIZ.

XXXIV.—PHILADELPHIA, NOVEMBER 15–17, 1881.

658. On a gigantic scalpa from the Gulf Stream. By A. AGASSIZ.
659. The echini of the Challenger expedition. By A. AGASSIZ.
660. Classification of the Dinosauria. By O. C. MARSH.
661. Mean annual rainfall for different countries of the globe. By ELIAS LOOMIS.
662. The porntidæ and velellidæ and the surface fauna of the Gulf Stream. By A. AGASSIZ.
663. On complex inorganic acids. By W. GIBBS.
664. On the Phenacodontidæ, a new group of Perissodactyla. By E. D. COPE.
665. Succession in time of the Allotheria. By O. C. MARSH.
666. The distribution of the corals of the Tortugas. By A. AGASSIZ.
667. A comparison between the shells of Kjokkenmoddings and present shells of the species. By E. S. MORSE.
668. On a form of regulator for the driving-clock of an equatorial. By C. A. YOUNG.

669. On the objects and results of the recent expedition to Mount Whitney. By S. P. LANGLEY.
670. Notice of a remarkable mineral vein in the Black range (Negretta Mountains) of Socorro County, New Mexico. By B. SILLIMAN.
671. Statement respecting experiments on the velocity of light. By SIMON NEWCOMB.
672. On the logic of number. By C. S. PEIRCE.
673. On hydrometer scales. By G. F. CHANDLER.
674. On chinoline, its synthesis and medical uses. By HENRY MORTON.
675. On the theory of the dynamo-electric machine. By W. GIBBS.
676. Facts regarding sorghum, and some conclusions as to its value as a source of sugar. (Read by B. Silliman.) By PETER COLLIER.
677. On Mascart's electrometer and its use as a meteorological instrument. By G. F. BARKER.
678. On the fossil and recent faunæ of the Oregon desert. By E. D. COPE.
679. On a new form of volumescope. By R. E. ROGERS.
680. The newly-determined line of the terminal moraine across Pennsylvania. By J. P. LESLEY.

Biographical memoir of S. F. Haldeman. By J. P. LESLEY.

XXXV.—WASHINGTON, APRIL 18–21, 1882.

681. On the course of the Gulf Stream since the Cretaceous period. By A. AGASSIZ.
682. Notes on the geology of Yucatan. By A. AGASSIZ.
683. The pre-Cambrian rocks of Italy. By T. STERRY HUNT.
684. On the brain of Phenacodus. By E. D. COPE.
685. On the young stages of a few osseous fishes. By A. AGASSIZ.
686. On the genesis and development of the Chiropterygium from the Ichthyopterygium. By T. GILL.
687. The affinities of Palæocampa, Meek and Worthen, as evidence of the wide diversity of type in the earliest known myriapods. By S. H. SCUDDER.
688. Preliminary notice of a new dividing engine. By H. A. ROWLAND.
689. On photographs of the spectrum of the nebula of Orion. By H. DRAPER.
690. Theory of concave gratings. By H. A. ROWLAND.
691. On the influence of time on the change in the resistance of the carbon disk of Edison's tasimeter. By T. C. MENDENHALL (by invitation of the Academy).
692. On the results of the incandescent lamp tests at the Paris Exhibition. By G. F. BARKER.
693. Note on a special form of secondary battery or electric accumulator. By W. GIBBS.
694. Researches on complex inorganic acids. By W. GIBBS.
695. Some discoveries that enhance the value of the cotton and orange crops. By C. V. RILEY (by invitation of the Academy).
696. The relation of rain areas to areas of low pressure. By E. LOOMIS.
697. Description of an articulate of doubtful relationship from the Tertiary beds of Florissant, Colorado. By S. H. SCUDDER.
698. Mythology of the Zuni Indians. By F. H. CUSHING (by invitation of the Academy).
699. On the polarization of the light of the moon. By A. W. WRIGHT.
700. On the infra-red portion of the solar spectrum as studied with the bolometer. By S. P. LANGLEY.
701. On the phenomena of metalliferous vein formation at Sulphur Bank, California. By JOSEPH LE CONTE.
702. On a form or standard barometer. By A. W. WRIGHT.
703. On a marsupial genus from the Eocene. By E. D. COPE.
704. On a fallacy of induction. By C. S. PEIRCE.

XXXVI.—NEW YORK, NOVEMBER 14-17, 1882.

705. On the mean annual rainfall. By E. LOOMIS.
706. On white phosphorus. By IRA REMSEN.
707. On a modified form of solar eye-piece for use of large apertures. By C. A. YOUNG.
708. On Triassic (?) insects from the Rocky Mountains. By S. H. SCUDDER.
709. Explanations on presenting a copy of the first ten numbers of the author's celestial charts. By C. H. F. PETERS.
710. On a method of studying the laws of contrast quantitatively. By O. N. ROOD.
711. On the existence in both hemispheres of a terrestrial dry zone and its cause. By A. GUYOT.
712. On a graphical method of representing the errors of a screw. By A. M. MAYER.
713. On the general equations of optics as derived from the electro-magnetic theory of light. By J. W. GIBBS.
714. On an improved form of standard Daniell cell. By G. F. BARKER.
715. On complex inorganic acids. By W. GIBBS.
716. On a sphereometer for measuring the radii of curvature of lenses of any diameter. By A. M. MAYER.
717. On a simple experimental demonstration of Ohm's law. By A. M. MAYER.
718. Lists of errors in star catalogues. By C. H. F. PETERS.
719. On the heat of the Comstock lode. By G. F. BECKER (by invitation of the Academy.)
720. On the physical and geological character of the sea-bottom off our coast, especially beneath the Gulf Stream. By A. E. VERRILL.
721. Co-operation in observing variable stars. By E. C. PICKERING.
722. On the topographical effects of faults and land-slides. By G. F. BECKER (by invitation of the Academy).
723. On the physical conditions under which coal was formed. By J. S. NEWBERRY.
724. On the fauna of the Puerco Eocene. By E. D. COPE.
725. On the total solar eclipse of May 6, 1883. By C. A. YOUNG.
726. On so-called eruptive serpentines. By T. S. HUNT.
727. On the place of the Echneididæ in the system. By T. GILL.
728. Remarks on the structure of the present comet. By C. H. F. PETERS.
729. On the effect of magnetism on chemical action. By IRA REMSEN.
730. On a form of kathetometer and comparator. By A. W. WRIGHT.
731. On the Permian genus Diplocaulus. By E. D. COPE.
732. On sinapic acid. By IRA REMSEN.
733. On the microscopic structure of some of the Brachiopoda with reference to their generic relations. By JAMES HALL.
734. On the origin of the carbonaceous matter of the bituminous shales. By J. S. NEWBERRY.
735. On the preparation of cyanin from chinoline. By C. F. CHANDLER.
736. On the logic of relatives. By C. S. PEIRCE.
737. On the determination of the figure of the earth by the variations of gravity. By C. S. PEIRCE.
738. On Ptolemy's catalogue of stars. By C. S. PEIRCE.
739. On the supposed human foot-prints recently found in Nevada. By O. C. MARSH.
740. On the meridian photometer. By E. C. PICKERING.

XXXVII.—WASHINGTON, APRIL 17-21, 1883.

741. On the genesis of metalliferous veins. By JOSEPH LE CONTE.
742. On the nascent state of oxygen. By IRA REMSEN.
743. On barometric gradients. By ELIAS LOOMIS.

744. On the structure of the skull in the *Hadrosauridæ*. By E. D. COPE.
745. Determination of the inequalities of the moon's motion which are produced by the figure of the earth; a supplement to Delauney's Theorie du movement de la Lune. By G. W. HILL.
746. On the decay of rocks geologically considered. By T. STERRY HUNT.
747. On the composition of the venom of serpents. By S. WEIR MITCHELL and E. T. REICHERT.
748. Maxima and minima tide producing machine. By W. FERREL. (Exhibition of machine.)
749. On changes in the properties of atoms and atomic groups, caused by change in position in the molecule. By IRA REMSEN.
750. On the measurement of wave lengths of heat. By S. P. LANGLEY.
751. On the spectrum of an Argand gas-burner. By S. P. LANGLEY.
752. Efficiency of storage batteries. By G. F. BARKER.
753. On the great object glass made by Alvan Clark & Sons for the Pulkowa Observatory. By OTTO VON STRUVE. (By invitation of the Academy.)
754. Photographs of the great comet of 1882. By C. H. F. PETERS.
755. Some experiments upon a method of forming a visible image of the solar corona. By A. W. WRIGHT.
756. On the phosphorescence of sulphate of quinine. By A. W. WRIGHT.
757. Further generalizations regarding complex inorganic acids. By WOLCOTT GIBBS.

XXXVIII.—NEW HAVEN, NOVEMBER 13–16, 1883.

758. Upon the formation of a deaf variety of the human race. By A. GRAHAM BELL.
759. On the solar eclipse of May 6, 1883. Reports by C. A. YOUNG, E. S. HOLDEN, and C. S. HASTINGS.
760. Notes on the mass of Saturn. By A. HALL.
761. The Animikie rocks of Lake Superior. By T. STERRY HUNT.
762. On some new primary cleavage forms of albuminous matter. By R. H. CHITTENDEN (by invitation of the Academy).
763. On the use of the word "light" in physics. By S. NEWCOMB.
764. On the subsidence of particles in liquids. By W. H. BREWER.
765. On a new photograph of the solar spectrum. By H. A. ROWLAND.
766. On the theory of errors of observation and probable results. By S. NEWCOMB.
767. On the stratified drift or terrace formation of the New Haven region, including its kettle holes and deserted river channels. By J. D. DANA.
768. Preliminary notice of phospho-vanadates, arsenio-vanadates, and antimonio-vanadates. By WOLCOTT GIBBS.
769. On the probable existence of new acids of phosphorus. By WOLCOTT GIBBS.
770. Notes on the mineralogy and lithology of the Bodie mining district of California. By B. SILLIMAN.
771. On the ancient glaciation of North America. By J. S. NEWBERRY.
772. Marriage institutions in tribal society. By J. W. POWELL.
773. Atmospheric absorption. By S. P. LANGLEY.
774. Note upon the physical aspects of the higher members of the Chemung group, and the development and distribution of the fossil genera Ptychopteria and Leptodesma, preceded by a review of the Pectenidæ and Aviculidæ of the Devonian system. By JAMES HALL.
775. Personality in the measures of Venus's diameter as derived during transit across the sun. By O. T. SHERMAN (by invitation of the Academy).
776. The reduction of barometric observations to sea-level. By ELIAS LOOMIS.
777. On the affinities of the Dinosaurian reptiles. By O. C. MARSH.

APPENDIX E.

REPORT ON METHYLATED SPIRITS.

[CORRESPONDENCE.]

YALE COLLEGE, NEW HAVEN, CONN.,
September 25, 1882.

Hon. GREEN B. RAUM,
Commissioner of Internal Revenue:

SIR: I inclose herewith a report made by a committee of the National Academy of Sciences, in response to your communication of April 12, 1882, requesting an investigation of the question whether methyl or wood spirits may be entirely or approximately separated from ethyl alcohol or spirits of wine.

Yours respectfully,

O. C. MARSH,
Acting President of the National Academy of Sciences.

Prof. O. C. MARSH,
Acting President of the National Academy of Sciences:

SIR: The following letter was received by the late Prof. W. B. Rogers, president of the National Academy of Sciences, from the Commissioner of Internal Revenue, General Green B. Raum:

TREASURY DEPARTMENT,
OFFICE OF INTERNAL REVENUE,
Washington, April 12, 1882.

SIR: There is now pending before Congress a bill (H. R. 5082) "to authorize the withdrawal from distillery warehouse, without tax, of alcohol and other spirits to be used in industrial pursuits," which bill provides that "such spirits shall either first have been mixed with one-ninth of their bulk of methyl or wood alcohol, of equal proof strength, or that such spirits shall be withdrawn for use in tobacco factories, or such other industrial pursuits as shall entail their complete destruction so that they cannot be recovered by any process of distillation."

It is therefore deemed important to the interests of the revenue that a careful and thorough investigation be made, having for its object the determination of the fact whether the methyl or wood spirits may be, entirely or approximately, separated by distillation, or in any other economical manner, from the ethyl alcohol or spirits of wine upon which the tax is imposed.

In other words, the information sought is as to whether the science of chemistry now enables the possessor of the methylated spirits to separate the ethyl alcohol from such mixture in such a state of purity and at such a probable cost as might enable the holder to sell it in the market at a less price than those persons who withdraw spirits from bond upon the payment of the tax at the rate of 90 cents per proof gallon.

I have therefore respectfully to request that a committee of the National Academy of Sciences be appointed to undertake this investigation, and to inform this office of the result at the earliest moment practicable.

I desire particularly to be advised as to the relative vaporizing point of purified wood-naphtha as compared with distilled spirits of the same specific gravity, and such other information on the subject as may assist this office in reaching a conclusion as to whether the bill referred to would be liable to abuse if it should become a law.

I have to ask if it is the pleasure of the academy to undertake this investigation, and if so, to be informed as to the nature and quantity of alcohol, wood-naphtha, and other materials which will be needed in the prosecution of this inquiry.

Very respectfully,

GREEN B. RAUM,
Commissioner.

Prof. W. B. ROGERS,
President National Academy of Sciences,
117 *Marlboro Street, Boston, Mass.*

In accordance with the above request, President Rogers appointed the undersigned committee. This committee having attended to the duty assigned to it, has the honor to present the following report:

The questions involved have several times been the subject of investigations. In England and Germany thorough investigations have been made. A law similar to the one proposed in the bill now pending before Congress has long been operative in England, and practically the same law has existed for a few years in Germany. Before the enactment of the law in England, the subject was thoroughly investigated by a committee consisting of Professors Graham, Hofmann, and Redwood. In their report to the chairman of inland revenue, dated July 24, 1854 (Journal of Chemical Society, vol. viii, p. 120), they took the ground that no economical method for separating wood spirits from ethyl alcohol was then known, and that the presence of the former even in very small quantity rendered the alcohol impalatable. The following recapitulation of their report will suffice:

> It has appeared that means exist by which spirits of wine produced in the usual way may be rendered unfit for human consumption as a beverage without materially impairing it for the greater number of more valuable purposes in the arts to which spirit is usually applied. To spirit of wine of not less strength than corresponds to density 0.830, it is proposed to make an addition of 10 per cent. of purified wood-naphtha, otherwise known as wood-spirit, pyroxylic and methylic spirit, and to issue the mixed spirit for consumption, duty free, under the name of "methylated spirit." It has been shown that methylated spirit resists any process for its purification, the removal of the substance added to the spirit of wine being not only difficult, but to all appearance impossible; and, further, that no danger is to be apprehended of the methylated spirit being ever compounded so as to make it palatable. The privilege of using such mixed spirit should be open to all branches of the arts and manufactures without restriction; but it may be expedient to prevent the sale of methylated spirit in licensed public houses, or the preparation and sale of it by the licensed rectifiers of spirits. The wood-naphtha employed in mixing should be supplied by the inland revenue, in order to insure uniformity in its quality, and that substance be

> mixed with the spirit at the distillery under Government inspection. The permission to use pure spirit of wine for any purpose of manufacture, under a bond of security, or in presence of a revenue officer, may reasonably be withheld till the methylated spirit now proposed has had a fair trial. It may be found safe to reduce eventually the proportion of the mixing ingredient to 5 per cent., or even a smaller proportion, although it is recommended to begin with the larger proportion of 10 per cent. The present supply of wood-naphtha is amply sufficient for the application contemplated of that substance, for mixing with the spirits used in the arts and manufactures of the country. The command of alcohol at a low price is sure to suggest a multitude of improved processes and of novel applications, which can be scarcely anticipated at the present moment. It will be felt far beyond the limited range of the trades now more immediately concerned in the consumption of spirits; like the repeal of the duty on salt, it will at once most vitally affect the chemical arts, and cannot fail ultimately to exert a beneficial influence upon many branches of industry. The same measure also practically removes one of the last anomalies in the duties imposed for revenue; alcohol having, as a raw material of manufacture, a claim to exemption from duty according to sound principles of taxation.

In some remarks, made in a supplementary report (January 8, 1855), they refer particularly to the possible use of the methylated spirit as a beverage, thus:

> On a review of the subject, and after further inquiries among manufacturers and others, we doubt whether it would be prudent to permit, at first, the retail sale of the methylated spirit. It has been represented to us that the unrestricted sale of the spirit would cause it to get into the hands of individuals of perverted tastes, who, in extreme cases, may use it for producing intoxication. Although we are satisfied that such a misapplication of the methylated spirit could only occur in some isolated instances among persons of confirmed habits of intemperance, yet it may be feared that even such cases would cause a public outcry against the measure before it had received a fair trial. We would, therefore, recommend that the methylated spirit should be issued, by agents duly authorized by the board of inland revenue, to none but manufacturers, who should themselves consume it, and that application should always be made for it according to a recognized form, in which, besides the quantity wanted, the applicant should state the use to which it is to be applied, and undertake that it should be applied to that purpose only.
>
> The manufacturer might be permitted to retail varnishes and other products containing the methylated spirit, but not the methylated spirit itself in an unaltered state.

In Germany the subject under consideration has also been fully investigated by Kraemer, Gerick, Dietze, and others. The results obtained by the three chemists named are summarized in Wagner's "Jahresbericht der chemishcher Technologie," 1878, p. 969. Kraemer recommends the use of the most impure varieties of wood spirit for mixing with ordinary alcohol. He selects for the purpose the first and last very impure products obtained in the distillation of crude wood spirit. These materials, he claims, render alcohol impalatable even to those with perverted tastes. It is further stated that the experience of years in countries in which wood-spirit is mixed with alcohol shows that there is little, if any, danger that the methylated spirit can be used as a beverage. The English chemists, on the other hand, recommended the use of *purified wood-naphtha* on the ground that it is just as difficult to separate this from alcohol as it is to separate the crude wood-naphtha, and that the latter renders the alcohol unfit for use in some of the arts.

As it is desirable that the nature of the substances to which reference is repeatedly made in this report should be clearly understood, the following statements in regard to them will be of service:

As is well known, the names *alcohol*, *ethyl alcohol*, *ordinary alcohol*, *spirits of wine*, are given to the same substance. This substance as ordinarily met with in the market consists of varying proportions of ethyl alcohol and water. It is never met with entirely free from water. In the pure state ethyl alcohol has the spe cific gravity 0.80207 compared with water at 4° C. Its boiling point is 78°.3 C. The alcohol received from the Commissioner, and which was used in the experiments described below, has the specific gravity 0.8144 at 20°.7 C.

Pure *methyl alcohol*, or wood-spirit, has practically no taste and no odor. It is not readily obtained and is hence expensive. It has the specific gravity 0.7896 at 24°. 5 C., and boils at ?

Crude wood-naphtha, or wood-spirit, obtained by distilling wood, removing the pyroligneous acid from the product, and then redistilling, is a complicated mixture of substances. The principal constituent is usually methyl alcohol. Besides this there are usually present acetone and oily substances, some of which have strong and disagreeable odors. The bad odor of wood-spirit is due to these impurities and is not a property ot the principal constituent—methyl alcohol. The proportions of the various substances contained in crude wood-naphtha vary according to the conditions surrounding the process of manufacture. As regards the specific gravities and boiling points of the different substances known as crude wood-naphtha very little of value can be said.

Purified or *refined wood-naphtha* or *wood-spirit* is the name given to the wood-spirit obtained as above described, and then subjected to certain processes which remove some of the impurities. The extent of the purification varies according to circumstances, so that the products known as refined wood-naphtha vary very much in their composition and properties. In our experiments we have had to deal with three different varieties of refined wood-naphtha. The differences between these were quite marked, as shown in the odors, boiling points, and specific gravities. The boiling point of one specimen was comparatively low in consequence of the presence of a considerable quantity of acetone. It began to boil at 58°, at which point the principal quantity of the acetone passed over. The boiling point then rose rapidly to that of methyl alcohol, and after the greater part of this had passed over, the boiling point rose still higher, but did not remain constant, a fact indicating that what was left in the distilling flask, after the acetone and methyl alcohol had distilled over, was a mixture of several substances. This is, in general, the conduct of all the specimens of refined wood-naphtha examined, though, as already stated, the proportions of the constituents are not in each case the same. The specific gravities of the specimens examined are:

Wood-spirit No. 1, 0.8149 at 30°.8 C.

Wood-spirit No. 2, 0.8186 at 20°.3 C.

Wood-spirit No. 3, 0.8374 at 24°.5 C.

The oily substances which give to wood-naphtha its odor cannot readily be removed completely, though they are removed partially by simple distillation.

Although the elaborate experiments of Graham, Hofmann, and Redwood, and of Kraemer, and Gericke, seem to show conclusively that alcohol to which wood-naphtha has been added cannot be again obtained in pure condition, the conclusion can hardly be regarded as final. The methods of distillation generally in use in chemical laboratories, and which were probably used in the experiments of the above-named chemists, are much less perfect than that which is used in the distillation of alcohol on the large scale. The "column-still," which the distillers use, is a much more efficient apparatus than those smaller forms of distilling apparatus which are in common use in chemical laboratories. Recently, however, some new forms of laboratory apparatus for distilling have come into use, and these approach more nearly in efficiency to the column-still. Among these, one of the best is that known as Hempel's tube. This consists of a glass tube about 1½ inches in diameter, and 3 feet long, filled with glass beads. The tube is inserted in the cork of the distilling flask, and the vapor of the distilled substance is caused to pass through the tube before it reaches the condenser. By this means some separations can be easily effected, which, without it are impossible in the laboratory. It was thought that this refined apparatus might accomplish the separation of wood-naphtha from alcohol—at all events, much more perfectly than the older forms of apparatus which have been used in earlier investigations.

Mixtures were made of alcohol and the three varieties of refined wood-naphtha above referred to, in the proportions prescribed by the bill. Each of the mixtures was then distilled with every precaution. A partial separation was effected, but the odor of the wood-naphtha was clearly recognizable in the best products obtained from these mixtures. The experiments were repeated a number of times, but we were unable to obtain even a small quantity of a product which did not unmistakably have the characteristic odor of the wood-naphtha. It appears from this that distillation alone, even with the most perfect instruments at the command of the chemist, cannot separate the wood-naphtha from ethyl alcohol so perfectly as to render the latter fit for use as a beverage.

The effect of bone-black was next tried. For this purpose freshly heated bone-black was used. The mixtures of alcohol with different kinds of wood-naphtha were allowed to stand for a length of time, varying in different cases from a few hours to a week. The mixtures experimented upon were also filtered through freshly-heated bone black.

While this treatment alone markedly improved the character of the alcohol, a strong odor was still left. The mixtures were then further distilled with the aid of the Hempel tube, and were further improved; but the best products obtained by this double treatment still had the odor of the wood-naphtha, though this odor was very much less marked than in the original mixtures.

Treatment with bone-black, together with distillation, is hence not sufficient to render the alcohol palatable; though this treatment improves it very much indeed.

The experiments which gave the best results consisted in treating the mixtures for some time with bone-black, and then distilling with the aid of the Hempel tube, and introducing into the alcohol before distillation a small quantity of caustic potash. In detail, we operated as follows:

The freshly-heated bone-black was put into the vessel containing the mixed alcohol, and the whole allowed to stand for about a day. The alcohol was then filtered from the bone-black, and a small quantity of caustic potash added. Then the liquid containing the alkali was distilled. The first product that came over boiled at a temperature below that of ethyl alcohol; this had a bad odor. Soon after the boiling point reached 78° (the boiling point of ethyl alcohol) the product which came over was nearly free from the disagreeable odor of wood-naphtha. By far the largest quantity of the product obtained in this distillation had very little odor. The last portion which came over had a disagreeable odor, but this was not much worse than that observed after distilling commercial alcohol of good quality.

It is unnecessary to describe, in detail, all the experiments we have performed. The final conclusion to which we are led is this: That by treating the mixtures of ethyl alcohol and wood-spirits (in the proportion proposed in the bill now before Congress) with bone-black, filtering, adding a caustic alkali—as, for example, caustic potash—and then distilling with the aid of the Hempel tube, the principal product obtained is nearly free from methyl alcohol, and that the odor and taste of this product are not very marked. At the same time, even in the best product thus obtained, the odor and taste characteristic of wood-naphtha can be detected, though only with difficulty, by those who are unskilled in such matters. We believe that the method employed by us which gave the best product could be applied economically on the large scale, and a product fully as good as our best, if not better than it, might thus be obtained.

As regards the question whether the product obtained could be used for drinking purposes, that is difficult for the committee to answer satisfactorily. We have submitted our best specimens to some well-known dealers in alcohol and alcoholic beverages, and we learn that the purified product might easily be used in the manufacture of low-grade whiskies and rum, though all the gentlemen whom we have consulted on this point have unhesitatingly recognized the presence of the wood-naphtha in the best specimens.

It would appear from this that, while, after the addition of the wood-naphtha to alcohol, it is extremely difficult, if not impossible, to separate the two perfectly and thus to regenerate the pure alcohol, it is quite possible to get from the mixture a product which might be used in the manufacture of alcoholic beverages of lower order.

It is plain from the foregoing that, considering our experiments as final, it is impossible to purify the mixture containing wood-naphtha to a sufficient extent to make it palatable without the aid of distillation. Hence, apparently, it would be as difficult to carry on the process of purification on the large scale as to carry on the illegitimate manufacture of alcohol. This fact, in itself, might be a sufficient protection against fraud, though the committee does not feel competent to express a decided opinion on this point.

IRA REMSEN,
C. F. CHANDLER,
G. F. BARKER,
Committee.

BALTIMORE, *September* 18, 1882.

APPENDIX F.

REPORT ON GLUCOSE.

CORRESPONDENCE.

YALE COLLEGE, NEW HAVEN, CONN.,
January 7, 1884.

Sir: I have the honor to transmit to you herewith a report on glucose, made by a committee of the National Academy of Sciences, in response to a request of your predecessor, Hon. G. B. Raum, dated April 27, 1882.

Very truly, yours,

O. C. MARSH,
President of the National Academy of Sciences.

Hon WALTER EVANS,
Commissioner of Internal Revenue.

Professor O. C. MARSH,
President National Academy of Sciences:

Sir: I have the honor to transmit to you herewith the report of the committee of the Academy, appointed to investigate the "composition, nature, and properties of the article commercially known as glucose, or grape sugar."

With high respect, I remain your obedient servant,

GEORGE F. BARKER,
Chairman.

PHILADELPHIA, *January*, 5, 1884.

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REPORT.

I.—GENERAL INTRODUCTION.

The present committee was appointed in accordance with a request contained in the following letter from the Hon. Green B. Raum, Commissioner of Internal Revenue of the United States:

TREASURY DEPARTMENT,
OFFICE OF INTERNAL REVENUE,
Washington, April 27, 1882.

SIR: There is now pending before Congress a bill (H. R. 3170) "to tax and regulate the manufacture and sale of glucose," which bill proposes to so amend the internal-revenue laws as to impose a special tax upon the manufacturers of, and dealers in, glucose, and to levy a tax on the article in its solid, liquid, and semi-liquid form.

In view of this, I have respectfully to request the appointment of a committee of the Academy to examine as to the composition, nature, and properties of the article commercially known as glucose, or grape sugar.

This office desires to be informed as to the saccharine quality of this product as compared with cane sugar or molasses, and also especially as to its deleterious effects when used as an article of food or drink or as a constituent element of such articles.

Numerous specimens of the article in question are in the possession of this office, which will be placed at the disposal of the Academy.

Any expense necessarily incurred in conducting this inquiry will be paid upon the presentation of a properly prepared bill for that purpose.

Very respectfully,

GREEN B. RAUM,
Commissioner.

Prof. W. B. ROGERS,
President National Academy of Sciences,
117 *Marlboro' Street, Boston, Mass.*

The lamented death of President Rogers, to whom this letter was addressed, occasioned some delay; so that the committee asked for, which was appointed by Professor Marsh, the acting president of the Academy, was not finally named until the 10th of June, 1882.

The meeting of the committee for organization was held in the city of New York on the 6th of July, 1882. After a full discussion of the questions submitted to the committee in the letter of Commissioner Raum, *it was decided:* 1st, to have a complete bibliography prepared of the literature of starch sugar;* 2d, to have the addresses of the starch-sugar factories in the United States obtained and the statistics of the manufacture collected; and, 3d, to have liberal samples of the various products procured, in order that their analysis might be complete and exhaustive.

To facilitate the latter part of the work a printed circular was prepared by the committee and mailed to twenty-four starch-sugar manufacturers, being all who were known at that time to the committee. A copy of this circular, including the inquiries contained in it, is appended to this report (Appendix 1). A complete list of the starch-sugar factories of the United States is also appended (Appendix 2). Those to whom the circular was sent are marked on this list with a star, the names of those parties from whom replies were received being given in a separate list immediately following. It will be observed that eighteen of these twenty-four factories responded to the circular. The replies to the questions were full and courteous, and every facility was offered to the committee for the furtherance of its investigations.

At an early meeting the chemical investigation, including the analysis of samples, was assigned to Professors Gibbs, Chandler, and Remsen, it being understood that the two first named should consider especially the inorganic constituents and impurities found in commercial starch-sugar, and the latter the organic substances present in it, together with the experiments on its physiological action and that of its fermentation products. The preparation of the bibliography of the literature of starch sugar and the statistics of the starch-sugar industry was referred to Professor Chandler.

It soon became evident to the committee that the subject which it had in hand was too extended to be satisfactorily investigated within the time allotted. A letter was therefore addressed to Commissioner Raum stating the facts and asking whether it was essential that the report of the committee should be presented to the Congress then in session. In his reply the Commissioner stated that he was satisfied that no legislation could be had upon the subject of glucose during that Congress; and therefore suggested that the committee take all the time for the investigation which they required.

Thereupon a somewhat more extended plan of operations was determined on. With the view of actually witnessing the manufacture of glucose and grape sugar, and of familiarizing themselves with the details of this manufacture upon a commercial scale, the members of the committee, upon invitation of Mr. Hiram Duryea, visited the extensive works of the Glen Cove Manufacturing Company, at Glen Cove, Long Island, N. Y. These works were in full operation at the time, and every facility was afforded the committee in its investigation of the various processes and in the procuring of samples. The committee also visited the works of the Manhattan Sugar Company, in New York City; but at the time of the visit these works were not in operation. Since the distance of the starch-sugar factories of the West rendered a personal inspection of these factories impracticable the committee selected Louis H. Laudy, Ph. D., of Columbia College, and commissioned him to make the tour of examination for them and to collect information and procure samples. This service he performed to the entire satisfaction of the committee. He went first to Buffalo, N. Y., where he visited the works of the Buffalo Grape Sugar Company, of the American Grape Sugar Company, and of the Firmenich Sugar Refining Company. He then proceeded to Chicago and visited the works of the Chicago Sugar Refining Company. On his return he stopped at Detroit and examined the works of the Michigan Grape Sugar Company. At all these factories he was cordially received and every opportunity was afforded him for witnessing the processes employed and for collecting samples of the products. In some cases the details of certain of the processes used were given to Dr. Laudy in confidence for the sole use of the committee. With these exceptions the information thus obtained has been used in drawing up the present report. The samples collected were distributed to the members of the committee for examination and report.

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* In commerce the term "glucose" is used to signify the liquid product, and "grape sugar" the solid product; the term "starch sugar" in this report includes both forms.

The chemical and physiological investigations went on uninterruptedly during the spring and summer months of 1883. The character of these investigations, including the methods which were employed and the results which were obtained, is given in the following pages:

II.—THE STARCH-SUGAR INDUSTRY.

1.—HISTORICAL.

The starch sugar of commerce consists chiefly of dextrose with varying quantities of another kind of sugar called maltose, and often more or less dextrin or starch gum.

Dextrose was first recognized as a peculiar variety of sugar, differing from cane sugar or saccharose, by Lowitz, in 1792, who prepared it from honey.

In 1811 Kirchhoff prepared it from starch by the action of dilute sulphuric acid.

In 1819 Braconnot prepared it from vegetable fiber or cellulose, such as linen rags, sawdust, etc., by the action of sulphuric acid.

It is generally known in chemical works as dextrose, or dextro-glucose, but is also called glucose, glycose, grape sugar, starch sugar, potato sugar, &c.

It occurs ready formed in honey, associated with cane sugar and levulose or levo-glucose; in most acid fruits, as the grape, &c., associated with levulose; in the manna of the ash tree, in diabetic urine, etc.

It is produced from cane sugar together with levulose, by the action of acids, yeast, etc., the mixed glucoses being called inverted or fruit sugar.

It is produced from starch by the action of dilute acids. It is also produced from vegetable fiber or cellulose by the action of sulphuric acid and also by a natural process during the ripening of some fruits, especially pears.

Dextrin and other carbohydrates also yield it by the action of acids. There is also a large class of organic bodies, which occur chiefly in plants, called glucosides, which yield glucose, together with other products, by the action of dilute acids or of peculiar ferments. Examples of this class are found in the amygdalin of bitter almonds, the salicin of willow bark, the myronic acid of mustard seed, the solanin of potato shoots, &c.

In 1847 Dubrunfaut pointed out the fact that the sugar produced from starch by the action of barley malt differed in some respects from dextrose, and proposed for it the name maltose.

O'Sullivan has shown that no dextrose is produced by malt, but that the product consists entirely of maltose and dextrin.

Maltose has since been found to be a constituent of most starch sugar. It often exceeds in quantity the dextrose, especially when the acid employed in the conversion has been very dilute, and the boiling continued for but a short time. Long boiling converts the maltose into dextrose.

2.—The Manufacture of Starch Sugar.

In France and Germany potato starch constitutes the only available material for the manufacture of this sugar, but in the United States the starch of Indian corn or maize is invariably employed.

The process consists, first, in extracting the starch from the corn in a state of sufficient purity, then transforming this into sugar by treatment with dilute acid, and subsequently neutralizing the acid, purifying, and then concentrating the product.

The details of the various steps differ in different establishments, but the general character of the process is the same as when first proposed in 1811 by Kirchhoff.

A.—Extracting the Starch.

1. *Steeping.*—The corn is placed in large wooden vats or tanks, holding from 500 to 1,000 bushels. It is covered with hot water, having a temperature of about 160° F. in summer, and 185° in winter. The corn immediately reduces the temperature of the water to about 140° or 145° F. Every six hours the water is drawn off and replaced with fresh water at about 130° or 135° F. If signs of fermentation appear the water is changed oftener; the object being to soften the corn, without permitting it to become sour. From two to four days steeping are required, the time depending on the hardness of the corn. Some manu-

facturers add to the water a little sulphuric acid, sulphurous acid, or caustic soda.

2. *Grinding.*—The softened corn is next ground between burr stones, a stream of water running continuously into the eye of the mill. As it is ground the thin paste is carried by the stream of water upon the shakers or sieves. Some manufacturers pass the paste through a second mill before it is sent to the shakers; others send it from the first mill to the shaker, and submit the husks to a second mill, employing a second shaker.

3. *Separation of the starch.*—The paste or pulp from the mill is passed over shakers, or starch separators. These are inclined sieves of silk bolting cloth, which are kept in constant motion, and sprayed with jets of water. The starch passes through the bolting cloth with the water, as a milky fluid, while the coarser cellular tissue or husk of the corn is left behind. This residue is pressed to remove water, and sold as cattle food.

4. *Cleansing the starch.*—The water from the shakers holding the starch in suspension is run either directly upon the tables or into wooden vats where the starch settles and the water is drawn off and discarded. The starch is next thoroughly agitated with fresh water, to which a small quantity of caustic soda, or carbonate of soda, has been added. The object in adding the alkali is to dissolve and remove the gluten and other albuminoids, oil, &c.

5. *Collecting the starch.*—The mixture of starch and alkaline water is allowed to flow upon long wooden runs, or tables, which are from 1 to 2 feet wide and 125 feet long. Twenty-five or fifty of these runs are required for the treatment of 1,000 bushels of corn daily. These runs have a slight incline, and as the cream flows slowly upon the upper end the starch is deposited, while the alkali wash, bearing lighter particles of cellular tissue, gluten, etc., flows off from the lower end. Some manufacturers prefer to treat the starch with alkali after it has been collected on the runs; while others treat it with alkali both before and after it goes on the runs.

6. *Washing the starch.*—The starch is next shoveled up from the runs and mixed with water, and then again allowed to settle. The water is drawn off, and the washing repeated, sometimes with a slight addition of hydrochloric acid; finally the thoroughly purified starch is mixed with the proper amount of water for the converter. The yield varies with the quality of the corn; a fair average would be, per bushel:

	Pounds.
Starch	30
Cattle food	14
Waste	12
Total	56

B.—TRANSFORMING THE STARCH INTO SUGAR.

7. *Conversion*, as it is termed, is accomplished in either open or closed converters; and in some establishments the process is partially executed in open and finished in closed converters.

The open converters are wooden vats, generally of 3,000 or 4,000 gallons capacity, sufficient for the treatment of the starch from 1,000 bushels of corn. They are provided with banks of copper steam-coils, either closed or perforated. The closed converters are generally of copper. They are provided with safety-valves, and are made of sufficient strength to withstand with safety a pressure of six atmospheres.

Sulphuric acid is generally employed in the conversion, though other acids have been used. The quantity of acid employed varies with the object of the manufacturer; for the production of "glucose," a liquid product, which contains much dextrin, a smaller quantity is used than when solid "grape sugar" is to be produced, in which the conversion into dextrose is much more complete. The proportion varies from one-half pound oil of vitriol to one and a quarter pounds per 100 pounds of starch.

When the *open converter* is used a few inches of water is introduced and the acid added, or half the acid may be added to the starch mixture. The acid water is brought to a boil, and the starch, previously mixed with water to a gravity of from 18° to 21° Baumé, is slowly pumped in, keeping the liquid constantly boiling. When the starch has been all introduced the whole is boiled until the iodine test ceases to give a blue and shows a dark cherry, or better an orange, color. The boiling is usually continued for from two to four hours.

When the *closed converter* is used the starch is mixed with water to a gravity of from 11° to 16° Baumé. This with the acid is introduced into the converter, and the whole is heated under a pressure of from 25 to 75 pounds per square inch. The time required for the conversion is much shorter than in the open converters.

The use of open and closed converters successively is often resorted to. The starch and water of a gravity of 15° or 16° Baumé is first boiled in the open converter for from one to two hours, then transferred to the closed converter and boiled under a pressure of from 25 to 75 pounds per square inch. The time of this boiling varies from ten minutes to half an hour.

The use of other acids.—C. Kroetke, in 1871, introduced in Germany the use of nitric acid in conjunction with sulphuric acid, in the proportion of two ounces of nitric acid to every pound of sulphuric acid.

Phosphoric acid has been patented as a substitute for sulphuric acid.

In 1858 R. Wagner suggested the use of oxalic acid in place of sulphuric acid.

E. Delarue & Co., of Paris, patented the use of oxalic or tartaric acid in 1879. Finally Bachet and Savalle state that under a pressure of eight atmospheres carbonic acid readily converts starch into dextrose.*

8. *Neutralization.*—When the starch has been sufficiently converted for the desired product, the liquor is run into the neutralizing vats. Here a sufficient quantity of marble dust is added to completely neutralize the sulphuric acid, converting it into sulphate of lime. In some cases the neutralization is completed with whiting.. A little fine bone-black is generally added just before and just after neutralizing. It is then allowed to cool and to deposit the sulphate of lime. A small portion of this sulphate of lime is retained in solution, and although most of this will be removed by the subsequent filtration through bone-black, a minute quantity is always found in the finished product. Kunheim & Co., in Berlin, propose to remove this by a small addition of oxalate of or phosphate baryta.

9. *Bag filtration.*—The liquor, having a gravity of 12° to 20° Baumé (light liquor), is next filtered through bag filters of cotton cloth or filter presses, or both.

10. *Treatment with sulphurous-acid gas.*—In many establishments this is resorted to at this point in the process to prevent fermentation, and probably to some extent as a bleaching agent.

11. *Bone black filtration.*—The liquor is now passed through bone-black filters, by which it is decolorized and at the same time freed from various other soluble impurities.

12. *Concentration* is effected in the vacuum pan at a temperature of from 130° to 140° F. until it has a gravity of from 28° to 33° Baumé. This is called heavy liquor.

13. *Second bag filtration.*—During the concentration a certain quantity of sulphate of lime separates, and it is found advisable to remove it when the liquor reaches the gravity of 28° or 33° Baumé. It is, therefore, filtered through the bag filter or filter press.

14. A second treatment with sulphurous acid is resorted to in some factories, the acid being added in the vacuum pan or to the liquor as it comes from the bag filte s.

15. *Second bone-black filtration.*—The heavy liquor is now filtered a second time through animal charcoal to secure a further decolorization, and purification.

16. The final concentration is accomplished by boiling the liquor in the vacuum pan till it exhibits a gravity of from 40° to 42° Baumé while hot. It is then let down from the pan and subjected to—

17. A third filtration through a filter press to remove the sulphate of lime which separates during the final concentration.

In some establishments the liquor is passed but once over bone-black; in fact all of the steps which have been mentioned are followed only by those manufacturers who desire to produce the best products.

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* The committee does not feel at liberty to publish the peculiar processes employed by the different factories, as these were communicated in confidence.

18. *Final treatment.*—The resulting product will vary in character according to the amount of acid used and the duration and temperature of the conversion. The variety in which the conversion has been least complete is called "glucose" in the trade and remains liquid. That in which the conver-sion is more complete, and which solidifies in the packages in consequence, is called "grape sugar."

An ingenious process has been invented by Dr. Arno Behr for causing the grape sugar to crystallize. While it is still liquid there is added to it a very small quantity of crystallized anhydrous dextrose. The mixture is filled into molds, and in about three days it is found to be a solid mass of crystals of anhydrous dextrose. The blocks are then placed in a centrifugal machine to throw out the still liquid sirup, and the anhydrous dextrose remains asa cr ystalline mass.

Starch sugar appears in commerce in a great variety of grades under the following names:

(*a.*) The liquid varieties—
  Glucose.
  Mixing glucose.
  Mixing sirup.
  Corn sirup.
  Jelly glucose.
  Confectioners' crystal glucose.
(*b.*) The solid varieties—
  Solid grape sugar.
  Clipped grape sugar.
  Granulated grape sugar.
  Powdered grape sugar.
  Confectioners' sugar.
  Brewers' grape sugar.

One establishment puts upon the market two varieties of starch sugar under the names—

1. Maltose, or maltose sirup for brewers,
2. Maize sugar or sirup, for confectioners,

and claims that they do not contain grape sugar (dextrose) but consist essentially of maltose.

The committee visited the factory, but it was not in operation, nor were the proprietors disposed to inform the committee of the nature of their processes, which they deemed it important to hold secret. They kindly supplied samples, however, and these are included in the list of analyses.

3.—MAGNITUDE OF THIS INDUSTRY.

The manufacture of starch sugar came into existence during the continental blockade which prevailed under Napoleon I. With the raising of this blockade the industry practically disappeared, as starch sugar could not compete with the colonial sugar of the cane.

The industry gradually revived, however, and finally acquired very considerable importance.

Although the committee has been able to secure a very complete list of all the starch sugar factories in the country, it has been found practically impossible to present any very clear idea of the magnitude of the business. This is due to the great irregularity of the working of these factories. When corn is low in price, and cane sugar, molasses, and barley high, all the establishments referred to are in full operation and the production of starch sugar is proportionally large. When the opposite conditions prevail, as they do at the present time, the starch sugar works are closed. Thirty-two factories exist in the United States, with a capacity ranging from 500 to 8,000 bushels of corn a day, most of them using about 2,000 bushels. The committee believes that it is safer to estimate an average capacity of 1,500 bushels; which would make the total capacity 43,000 bushels per day.

The Census Bulletin No. 304 gives seven glucose factories, with a capital of $2,255,000, and a gross value of products of $4,551,212.

Payen, in the third edition of his Chimie Industrielle, published in 1855, places the French production of potato starch sugar at 5,000,000 kilograms or 5,500 tons per annum.

The manufacture of starch sugar from potatoes is an old manufacture in Germany, and very complete statistics showing its extent have been published from time to time. Wagner, in the second edition of his Chemische Technologie, states that there were in 1874 sixty glucose factories in the German Empire, with an annual production of 360,000 centners (19,800 tons) sirup and 500,000 centners (27,500 tons) solid sugar. Post, in his Chemische Technologie, places the production during the fiscal year 1877–'78 of the 45 factories in Germany at 5,931 tons starch sirup and 8,135 tons starch sugar, at a price for the sugar varying from $82.50 to $84 per ton.

It is stated in Wagner's Jahresbericht for 1877 that 2,221 tons of starch sugar were used in the manufacture of beer in Germany during the year 1876. The following table, giving the production for the fiscal year 1881–'82, is translated from Wagner's Jahresbericht der Chemischen Technologie for 1882:

Production of starch sugar in the German Customs Union in fiscal year 1881–'82 *in tons of* 2,000 *pounds.*

States and provinces.	Number of factories.	Quantity of starch converted.				Quantity of sugar made.			Average selling price, per 2,000 pounds.		
		Starch made.		Starch purchased.							
		Moist.	Dry.	Moist.	Dry.	Grape sugar (solid).	Glucose (liquid).	Sugar color.	Grape sugar (solid).	Glucose (liquid).	Sugar color.
Prussia:											
Province of Brandenburg	15	18, 961	2, 055	32, 852	11	14, 920	14, 705	834	$62 30	$63 90	$83 25
Province of Pomerania	*4	192	....	131	....	167	27	....	54 00	67 25	....
Province of Posen	1	333	....	1, 729	....	199	806	242	54 00	58 50	58 50
Province of Silesia	4	942	....	8, 333	....	1, 566	372	289	53 55	54 45	89 55
Province of Saxony	4	2, 279	226	1, 093	....	1	1, 476	346	67 50	61 65	78 98
Rhine provinces	2	1, 333	....	....	....	888	....	....	72 00	....	....
Total	30	24, 045	2, 281	44, 138	11	17, 742	17, 386	1, 711	61 87	63 45	79 87
Bavaria	1	....	....	....	....	40	....	....	67 25	....	....
Baden	1	....	....	....	....	....	....	....	....	....	....
Hesse	*3	528	3	....	44	461	....	....	65 25	....	....
Mecklenburg	1	861	....	....	....	....	533	....	....	54 00	....
Brunswick	1	500	....	....	....	....	333	....	....	47 25	....
Alsatia	2	936	....	331	142	342	528	....	67 25	81 00	....
Customs Union, 1881–'82	†39	26, 869	2, 284	44, 469	197	18, 384	18, 782	1, 711	62 10	63 22	79 87
In fiscal year 1880–'81	†45	21, 862	911	28, 680	362	11, 768	17, 970	855	74 25	72 00	82 35

* Of these, two were not running.

† Of these, four were not running in 1881–'82 and seven in 1880–'81.

4.—USES OF STARCH SUGAR.

Both glucose and grape sugar find extensive application for a great variety of purposes as substitutes for cane sugar or for barley.

The most general purposes for which starch sugar is used are—

1. For the manufacture of table sirup. This consists of a nearly or quite colorless glucose, with a sufficient addition of the cane sirup from the sugar refinery to give it the flavor and appearance of a highly refined molasses. The quantity of cane sirup added varies from 2 per cent. up to perhaps 33 per cent.

2. As a substitute for barley malt in the brewing of ale or beer. This is really a substitution of Indian corn for barley; but it constitutes a very imperfect substitute, as the corn by the treatment employed in extracting its starch for conversion into glucose is completely deprived of all the nitrogenous bodies and mineral salts which it originally contained. Hence the glucose alone, which is simply transformed starch, is substituted for the entire barley grain with its great variety of valuable constituents. This is not true, however, of the maltose produced from the entire corn by the action of malt. This material contains all the soluble constituents of the corn, together with the additional substances which are rendered soluble by the action of the diastase of the malt.

3. As a substitute for cane sugar in confectionery.

4. For the adulteration of cane sugar, to which it is added to the extent of 20 or more per cent.

In the appendix will be found some analysis of commercial cane sugar.* Although the committee has the most positive evidence that grape sugar has at times been used to a considerable extent in adulterating cane sugar, yet the samples of commercial sugar which have been collected from time to time in New York City by the inspectors of the city and State boards of health have never shown any such addition.

5. As a substitute for cane sugar in canning fruits and in the manufacture of fruit jellies.

6. For the manufacture of artificial honey. This is neatly put up in glass jars containing a small piece of genuine honeycomb.

7. In the manufacture of vinegar.

8. In the manufacture of liquor coloring, used both in mixing liquors and in making artificial liquors.

9. Other more limited applications: In the manufacture of wine; by the baker in making cakes; in cooking, in the preparation of sauces; as an addition to some canned meats, especially corned beef; in the preparation of chewing tobacco; in the manufacture of printers' rollers, and in the manufacture of some kinds of ink.

The demand for glucose and grape sugar for these purposes is extremely variable, and depends on the relative prices of corn and of the articles for which this kind of sugar is substituted, especially sugar-house sirup and barley.

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* See Appendix 3 of this report.

III.—ON THE NATURE OF THE COMMERCIAL PRODUCTS.

1.—VARIETIES OF SUGAR.

Before giving the methods of analysis employed and the results obtained, it is desirable that the meaning of the names of the substances should be stated as clearly as possible, in order that those who are not chemists may be able to read the report understandingly.

Sugar is to the chemist a collective name. There are two classes of sugars, closely related to each other. Of one of them our ordinary cane sugar, as well as beet sugar, which is chemically identical with cane sugar, are examples. Of the other class, grape sugar, glucose or dextrose, the sugar of grapes and honey, is the principal example. Another example of the grape-sugar group is levulose. Dextrose and levulose have the same chemical composition, but different properties. The difference between them is especially marked in connection with the action upon polarized light. While the former (dextrose) turns the plane of polarization to the right, the latter (levulose) turns it to the left. Pure dextrose is stated to have about three-fifths the sweetening power of cane sugar.

When cane sugar is boiled with a dilute acid, as sulphuric or hydrochloric acid, it is converted into equal parts of dextrose and levulose, the mixture being called fruit-sugar.

The names "grape sugar," "glucose," and "dextrose," when used by a chemist, are meant to designate the same substance. In commerce, however, as already stated, the names "grape-sugar" and "glucose" have a somewhat different meaning, the former being applied to the solid and the latter to the liquid products.

One of the first problems which presented itself to the committee in the examination of the collected samples of grape sugar and glucose was the determination of their composition. Assuming that in the process of manufacture perfectly pure starch, acid, and water were used, that nothing foreign was introduced, and that the transformations were carried to the end, the product would be pure dextrose. But the conditions under which the manufacturers work permit of considerable variations in the composition of the products. In the first place, the transformation of the starch into dextrose may not be perfect. Indeed, if sulphuric acid be used to effect the transformation, it is impossible, even under the most favorable conditions, to transform more than 95 per cent. of the starch into dextrose. The extent of the transformation is dependent upon the strength of the acid, the temperature, and the time during which the heating is continued. The intermediate products are chiefly maltose and dextrin, which may be present in greater or smaller quantities, according to the way the process is carried out. If the product is to be used in the form of sirup, then the presence of dextrin is objectionable, as it has no sweetening power, though it does not produce injurious effects upon the system. If it is to be used in the manufacture of beer, it should be borne in mind that dextrin does not undergo fermentation. Again, the products may be more or less contaminated by mineral substances, such as salts of lime, which are commonly used in the manufacture. Hence, in the analysis of our samples, we directed attention, first, to the substances formed by the transformation of the starch, and, second, to the accidental mineral impurities.

2.—ORGANIC CONSTITUENTS.

Many analyses of the commercial products have been made by others, but we have thought best to collect samples ourselves from some of the important factories of the country taken at random, and to have analyses made under our own supervision, for the purpose of ascertaining how nearly the various products met with in the market approach the same composition.

The samples collected, as stated in full in the first part of the report, were divided into the necessary number of parts and one part of each was forwarded to each member of the committee. The bottles and packages were simply numbered, and the members of the committee had no knowledge of the original source of the samples. In the results which will be given below the samples will be referred to only by their respective numbers. The estimations of the relative quantities of dextrose, maltose, and dextrin were made by Mr. A. G. Palmer, of the Johns Hopkins University, who used for the purpose a method suggested by H. W. Wiley (Chemical News, vol. 46, p. 175). The theory of the process may be stated in a few words. All three of the bodies present, viz, dextrose, maltose, and dextrin, are optically active, turning the plane of polarization to the right though not to the same extent, the specific rotatory power of dextrose being 52, that of maltose 139, and that of dextrin 193. Now, if a solution containing all three is examined with a polariscope the total rotation observed is due to the action of the three—

$$P = 52\,d + 139\,m + 193\,d' \quad . \; . \; . \; . \; . \; . \; . \quad (1).$$

If the solution be treated with mercuric cyanide in excess, all the dextrose and maltose will be destroyed and only the dextrin left unchanged. If a second observation be now made with the polarizing apparatus, the rotation observed will give the quantity of dextrin present, for we have—

$$P' = 193\,d' \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2),$$

from which the value of d′, or the amount of dextrin, may be easily calculated. Subtracting (2) from (1) we have—

$$P - P' = 52\,d + 139\,m \quad . \; . \; . \; . \; . \; . \; . \; . \quad (3).$$

When a mixture of the three substances is treated with Fehling's solution the dextrose and maltose are reduced. The total reduction gives, then, the reducing per cent. of the dextrose d, + that of the maltose m. Since maltose, however, has a reducing power as compared with dextrose of only 0.62, we have the equation—

$$R = d + 0.62\,m \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4).$$

Multiply this by 52, which gives

$$52\,R = 52\,d + 32.24\,m,$$

and subtract from (3). This gives

$$P - P' - 52\,R = 106.76\,m \quad . \; . \; . \; . \; . \; . \; . \quad (5).$$

Whence

$$m = \frac{P - P' - 52\,R}{106.76} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (6)$$

$$d = R - 0.62\,m \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (7)$$

and

$$d' = \frac{P'}{193.}$$

For further details of the process reference is made to the paper by Wiley.

The copper solution used is made up in proportions stated below:

	Grams.
Copper sulphate	34.632
Sodium potassium tartrate	173
Potassium hydrate	125

The substances were dissolved in water and the solution diluted to one liter.

The mercuric cyanide solution used contained in 1 liter 120 grams mercuric cyanide and 25 grams of potassium hydrate. Twenty-five c. c. of this solution was sufficient for solutions containing not more than 65 per cent. of reducing substances, and 30 c. c. for solutions containing more than that amount.

The copper solution (10 c. c.) diluted with its own volume of water was in all cases contained in a small Erlenmeyer flask. After heating to boiling the sugar solution was run in and the whole again heated to boiling. For the first trial experiment, the sugar solution was added in small portions at a time until the blue color disappeared. The approximate amount of the sugar having thus been determined, several new titrations were made, the sugar solution being added all at once, until two successive titrations differing by 2 c. c. in the amount of sugar solution added, the first giving the copper reaction with potassium ferocyanide, and the second not giving it, were obtained.

Water was estimated directly by mixing the sample in a small porcelain dish with clean dry sand, and heating in an air bath for three hours at 110°. In some cases, as of maize sirup, family sirup, and maltose sirup, three hours was found to be too long, as in that time the sample was largely converted into caramel.

TABLE I.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Per cent. reducing matter	48.5	43.6	42.7	39.3	....	41.2	73.8	87.3	93.2
Total rotation	20°.7	19°.7	21°.7	19°.33	....	21°.7	9°.7	9°.17	10
Rotat. after mercuric cyanide	11°.5	14°.9	16°.3	4°.33	....	15°.8	1°.65	0°.0	0°.0
Per cent. water	14.2	17.4	16.1	22.6	....	15.3	15.1	12.4	7.3

	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
Per cent. reducing matter	99.37	....	74.2	74.2	41.0	72.1	41.9	39.0	37.2	40
Total rotation	10°.4	....	11°	11°.5	20°.66	11°	19°.5	20°.1	22°.33	18°.66
Rotat. after mercuric cyanide	0°.0	....	2°.5	3°.5	15°	3°.5	15°	16°	17°.5	12°.5
Per cent. water	0.62	....	17.5	14.0	19.2	16.6	20.6	19.3	17.2	17.0

TABLE II.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Per cent. dextrose	36.5	42.8	39.8	38.6	....	36.5	72.7	87.1	93.2
Maltose	19.3	1.3	4.7	1.1	....	7.6	1.8	.3	....
Dextrin	29.8	38.4	42.1	38.8	....	40.9	4.2	....	....
Water	14.2	17.4	16.1	22.6	....	15.3	15.1	12.4	7.3
Total	99.8	99.9	102.7	101.1	....	100.3	93.8	99.8	100.5

	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
Per cent. dextrose	99.4	....	72.0	73.4	37.0	72.1	41.5	39.0	34.3	40.0
Maltose	....	....	3.6	1.3	6.5	....	.6	....	4.6	....
Dextrin	....	....	6.4	9.1	38.8	9.1	38.8	41.4	45.3	32.4
Water	0.6	....	17.5	14.0	19.2	16.6	20.6	19.3	17.2	17.0
Total	100.0	....	99.5	97.8	101.5	97.8	101.5	99.7	101.4	89.4

For these samples, one and a half hours was found to be long enough. The figures obtained in each case were—

1. Percentage of reducing matter;
2. Total rotation;
3. Rotation after treatment with mercuric cyanide; and,
4. Percentage of water.

Nineteen numbered samples in all were sent for examination; of these, seventeen were analyzed, No. 5 being wanting in the lot as received, and No. 11 evidently being a sample of impure cane sugar. In Table 1 the figures are given as obtained, and in Table 2 the percentages of the constituents are given as calculated by the method given above.

Numbers 7, 8, 9, 10, 12, 13, and 15 were solids, the others liquids. Nos. 7 and 19 evidently contained considerable burnt sugar, to which fact the curious results obtained in the analysis are at least partly to be attributed.* Nos. 8, 9, and 10 are specially pure specimens of grape sugar, and certainly do not represent the average composition of commercial grape sugar. As fair samples of commercial grape sugar, Nos. 7, 12, and 13 and 15 may be taken. In these, as will be seen, the amount of dextrose present is between 72 and 73.4 per cent., while the dextrin varies from 4.2 to 9.1 per cent.

As regards the liquid products, the so-called glucoses, it will be seen that the amount of dextrose present in them varies from 34.3 to 42.8 per cent., and the amount of dextrin from 29.8 to 45.3 per cent.

It should be said that the constituents thus far mentioned are of themselves not injurious when taken into the system, though, as above stated, the dextrin has no sweetening power, and hence it has no value as a constituent of table sirups or sugars.

3.—INORGANIC CONSTITUENTS.

The results obtained in the examination of the samples for mineral impurities are here given. The analyses were made by J. S. C. Wells, Ph. D. of the School of Mines of Columbia College :

Samples of starch sugar examined.

Mark.	Factory.	Water.	Ash.	Sulphuric acid (So_3).	Chlorine.	Ferric oxide.	Lime.	Magnesia.	Alkalies.
No. 1. Glucose	A*	11. 50	0. 325	0. 202	0. 055	0. 020	0. 012	0. 027	0. 097
No. 2. Mixing sirup	A	17. 15	0. 370	0. 177	0. 060	0. 015	0. 008	0. 023	0. 140
No. 3. Glucose	B	12 18	0. 520	0. 039	0. 255	0. 030	0. 066	0. 005	0. 157
No. 4. Mixing sirup	B	24. 25	0. 890	0. 220	0. 155	0. 015	0. 014	0. 031	0. 380
No. 6. Glucose	C	14. 50	0. 420	0. 161	0. 065	0. 010	0. 014	0. 025	0. 150
No. 7. Brewers' grape sugar	D	12. 98	0. 380	0. 055	0. 010	0. 055	0. 024	0. 038	0. 070
No. 8. Confectioners' grape sugar	D	10. 00	0. 140	0. 091	0. 010	0. 025	0. 025	0. 007	0. 017
No. 9. Cakes from centrifugal	D	4. 20	0. 220	0. 139	0. 020	0. 035	0. 035	0. 023	0. 016
No. 10. Anhydrous grape sugar	D	0. 53	0. 025	0. 009	0. 000	0. 006	0. 004	0. 004	0. 000
No. 11. Mixed grape and cane sugar	D	1. 75	0. 330	0. 029	0. 120	0. 025	0. 025	0. 004	0. 120
No. 12. Grape sugar	A	13. 25	0. 495	0. 230	0. 050	0. 100	0. 047	0. 004	0. 140
No. 13. Grape sugar	E	11. 55	0. 750	0. 395	0. 025	0. 030	0. 029	0. 004	0. 320
No. 14. Glucose	F	23. 10	0. 335	0. 094	0. 105	0. 010	0. 012	0. 009	0. 134
No. 15. Grape sugar	F	16. 50	0. 335	0. 159	0. 050	0. 055	0. 027	0. 004	0. 102
No. 16. Maltose	G	22. 26	1. 060	0. 056	0. 125	0. 000	0. 021	0. 101	0. 337
No. 17. Maize sirup	G	24. 46	0. 815	0. 065	0. 120	0. 010	0. 008	0. 013	0. 374
No. 18. Glucose	H	18. 41	0. 335	0. 053	0. 025	0. 015	0. 080	0. 034	0. 012
No. 19. Family sirup, mixed cane and grape	H	21. 17	1. 535	0. 094	0. 205	0. 040	0. 226	0. 088	0. 340

* The capital letters in this column are not the initials of the firms or factories from which the samples were taken; they simply indicate that samples having the same letter came from the same factory.

Careful research was made for tin, copper, and other metallic impurities, but none were found.

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*No. 19 was a mixture of glucose and cane molasses, which accounts for the results of the analysis, the cane sugar present interfering with this method of analysis.

Sample No. 16 gave, when fermented, results which lead us to the belief that it contains a large amount of maltose and very little if any dextrose. From this and some other facts noticed in the course of the work, we conclude that the method of Wiley is not applicable to products containing any considerable percentage of maltose.

Sulphuric acid and chlorine were determined in the solution of the original samples, ten grains being used in each case. Oxide of iron, lime and magnesia were determined in the ash. The ash itself was determined by moistening 10 grains of the material with 3 or 4 c. c. of sulphuric acid, and then incinerating.

The French plan of deducting one-tenth from the weight of the ash for the sulphuric acid added was not, however, adopted.

To secure an approximate determination of the alkalies, the lime and magnesia were calculated as sulphates, and with the oxide of iron were subtracted from the total ash, the residue being counted as alkaline sulphates, and, divided by two. The result represents approximately the alkalies.

IV.—IS THE USE OF "GLUCOSE" OR "GRAPE SUGAR" INJURIOUS TO HEALTH?

This is certainly one of the most important questions that can be asked regarding the substance under consideration. It has been discussed very freely, but on a very insufficient basis of facts. Indeed, so far as the products made from corn starch are concerned, it appears that no experiments have ever been made with reference to their effects upon the system. It is essential in a discussion of this subject to keep clearly in mind the fact that while it is undoubtedly true that the pure chemical substances—dextrose, maltose, and dextrin—are not injurious, there may be other substances present in small quantities in the commercial products, and that these may be capable of producing injurious effects. Or it may be true that when the commercial products are changed by fermentation, substances of injurious character are formed or left unfermented.

In Germany, where large quantities of dextrose are made from potato starch, experiments bearing upon the question of the presence of injurious constituents have been made with the commercial products. Some of the results obtained indicate that after fermentation of potato sugar, there are left substances which are injurious, while others indicate that this is not true. Among those who have experimented on the subject, A. Schmitz, Nessler, and Freiherr von Mering should be specially mentioned. Schmitz (Beiträge zur diätetischen Beurtheilung des gallisirten Weins, Köln, 1878) fermented potato sugar, and, evaporating the products down to small volumes, administered known quantities of the residues to cats and dogs, and in a few cases to human beings. The results obtained were uniform, and showed that the substances caused sickness, as headache, sweating, and loss of appetite.

Later Nessler (Wochenblatt des Landwirthschaftlichen Vereins in Grossherzogthum Baden, 1880) undertook similar experiments and obtained similar results. He experimented upon his assistant and himself. One of his experiments is here described: He allowed a 20 per cent. solution of potato sugar to ferment after the addition of a small quantity of hops. After the fermentation was over the liquid was filtered, a liter evaporated down to a sirup, and then diluted up to 100 c. c. This solution had a disagreeable, bitter taste. Nessler took 50 c. c. of it at 7 a. m., and the same quantity at 10 a. m., each portion corresponding to 100 grams of potato sugar. Toward noon he began to feel uncomfortable, but not so much so that he could positively attribute his condition to the beer extract. At 2 p. m. the residue from 100 grams potato sugar was again taken, and now, in about an hour, there followed profuse perspiration and violent headache, both of which continued until night. A few days later his assistant took the residue from 90 grams sugar, the fermented liquor having been evaporated down to two-fifths its original volume. He soon experienced difficulty in breathing and broke out in a cold sweat; at dinner he had no appetite, and was obliged to throw up the little soup he did take. In the afternoon he had a violent headache, which continued until evening.

Nessler concludes his paper with these words:

> It is, hence, beyond a doubt true that in the liquid obtained in the fermentation of potato sugar there are substances injurious to health. If the question is asked whether this is true of all commercial potato sugars, as well as of the sugar examined, we cannot give a definite answer.
>
> In the case of all varieties of potato sugar thus far examined there remains, after evaporation of the fermented liquid, a bitter-tasting extract, which turns the plane of polarization to the right, and it is very probable that all of them may act injuriously upon the health in varying degrees, according to the greater or less purity.
>
> As in buying the sugars it is not possible to determine whether the harmful substances are present or not, potato sugar should not be used for the preparation of beverages* until it can be prepared in perfectly pure form.

Directly opposed to the results of Schmitz and Nessler are those obtained by Freiherr von Mering (Deutsche Vierteljahrschrift für öffentliche Gesundheitspflege, Vol. 14, p. 325).

This writer experimented upon dogs, cats, rabbits, and human beings in much the same way as Schmitz and Nessler had done, and he concludes that the unfermentable residues from potato sugar are not at all objectionable.

Later Schmitz (Deutsche Vierteljahrschrift für öffentliche Gesundheitspflege, Vol. 14, p. 481) replied to Von Mering, upholding his first results.

It hence appears doubtful whether there are injurious substances in potato sugar, and it is highly desirable that the experiments on this subject should be repeated by those who have not thus far taken active part in the discussion. Even though it should eventually be shown that potato sugar is or is not objectionable, it would not necessarily follow that the same is also true of maize sugar.

As, so far as we know, no experiments had been made upon starch sugar, we carefully repeated the experiments described above, using several of the samples of glucose and grape sugar, the analysis of which are given in the preceding part of this report.

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*One of the uses to which potato sugar is put in Germany is as an addition to poor wine.

We were fortunate in securing for this work the assistance of Dr. J. R. Duggan, of the Johns Hopkins University, who has for some time past been occupied in experiments upon fermentation, and who is hence fully familiar with all the precautions necessary to secure reliable results. The fermentations were carried on in a new cellar which, fortunately, chanced to be available, so that the danger of abnormal fermentation was reduced to a minimum.

Pure glucose cannot be fermented by the simple addition of yeast in small quantity, for yeast, like all living matter, requires certain nitrogenous and inorganic materials for its own nourishment. As has been shown by Pasteur, this want may be supplied by the addition of certain salts, such as ammonium tartrate, calcium phosphate, etc., but as these cannot be added in exactly the necessary proportions, some would be likely to remain in the solution after fermentation was complete, and, if taken into the stomach along with the glucose residue, would probably produce an effect of its own which might be attributed to the glucose.

It is not easy to obtain in sufficient quantity a liquid furnishing a proper medium for the growth of yeast which does not also contain glucose; and, for this reason, it was first necessary to determine the effect, if any, of the unfermentable residue from this glucose.

Experiments Nos. 1, 2, and 3 were made for this purpose. The nutrient liquid used was barley wort, on account of the fact that it is most commonly used in brewing for commercial purposes.

This liquid contains much more nitrogenous matter than is necessary to support the yeast during its fermentation, and therefore it still forms a good medium for the growth and development of yeast after it is considerably diluted with a solution of glucose.

The method of experimenting was as follows:

The barley wort of the concentration usually employed for making beer was mixed with the glucose solution, and the whole heated to boiling by passing steam through a coil of block-tin tubing placed in the tub. The tube was then connected with the hydrant and water passed through it until the solution was well cooled. It was then allowed to flow slowly over a wide board for the purpose of thoroughly aerating it. The temperature was reduced to about 10° C. and about a pint of yeast added. Fermentation was carried on in a cool vault, and was allowed to continue until very little sugar was left in the solution and the yeast had all settled to the bottom of the tubs. A sufficient quantity of beer was then siphoned off and evaporated slowly over the water-bath to about one-tenth its volume. The residue consisted principally of dextrin, nitrogenous matter from the wort, glycerin, succinic acid, and probably other products of fermentation in very small quantities. It formed a thick, dark-colored sirup of very disagreeable taste, especially when wort containing hops had been used. For this reason sweet wort was used in most of the experiments. All of the fermentations were carried on by the low process, that is, with bottom yeast at a temperature of from 8° to 10° C.

Two experiments were tried with the high process, but it was found to be impracticable on the small scale on account of the development of bacteria due to the higher temperature. As the difference in the two processes is essentially one of temperature only, there is no reason to suppose that they could in any way give different results.

The amount of yeast added to each tub was about one-half liter. This was carefully examined with the microscope both before and after fermentation, to guard against the presence of foreign ferments that might produce injurious products. The glucoses used were of the various manufactures already mentioned, and embrace the different grades of solid and liquid products.

The extracts were taken at different hours of the day, both before and after meals. The quantity usually taken contained the residue from 125 grams of glucose, but in Experiment No. 8 this quantity was increased so as to correspond to 200 grams. It seemed useless to try still larger quantities, for it is probable that if much more was taken the normal products of fermentation, such as succinic acid, would produce some effect.

EXPERIMENTS 1 AND 2.—Thirty liters of sweet wort and the same quantity of hopped wort were separately fermented, the process lasting in each case one week. Five liters of the resulting liquid were evaporated to 750 c. c., and 300 c. c. of the extract taken internally. The same experiment was tried by two individuals, but no effect was produced. The amount of extract taken corresponded to 2 liters of the beer.

EXPERIMENT 3.—In this experiment there were used 15 liters of sweet wort, to which were added 15 liters of a 12.5 per cent. solution of cane sugar. Five liters of the liquid were evaporated to 500 c. c., and 200 c. c. of the extract taken with no effect. The amount of extract taken represented 125 grams of cane sugar.

EXPERIMENT 4.—Fermented 15 liters sweet wort and 15 liters of a 12.5 per cent. solution of grape sugar (sample No. 12). Five liters of the liquid were evaporated to 500 c. c., and 200 c. c. taken. No effect was produced. On the following day the same amount of residue was taken and with no effect. The amount of extract taken corresponded to 125 grams of glucose in each experiment.

EXPERIMENT 5.—Fifteen liters of sweet wort and 15 liters of a 12.5 per cent. solution of grape sugar (sample No. 7) were fermented. The same amount of extract was taken as in the last experiment, with the same results.

EXPERIMENT 6.—The details of this experiment were exactly the same as those of the last. The substance was a commercial glucose (sample No. 14).

EXPERIMENT 7.—Fifteen liters of hopped wort, with 7.5 liters of a 25 per cent. solution of commercial glucose (sample No. 1), were fermented. Four liters of the fermented liquid were evaporated down to 400 c. c., and of the residue 150 c. c. were taken. No effect was felt.

EXPERIMENT 8.—Fifteen liters of hopped wort and 7.5 liters of a 25 per cent. solution of grape sugar (sample No. 13) were fermented. Five liters of the fermented liquid were evaporated to 500 c. c., and 200 c. c. taken. No effect was felt. The extract taken represented 160 grams of grape sugar.

The experiments described above occupied about two months, during which time Dr. Duggan repeatedly took large quantities of the extracts. At the end of the experiments, and during the entire period, his health continued excellent.

There was nothing whatever to indicate that the extracts contained anything injurious to health, and the conclusion seems to be fully justified that the samples examined by us, and which we have every reason to believe were fair average samples of the substances found in the market, contained nothing objectionable from a sanitary standpoint. In the experiments the experimenter took into his system everything that could possibly be objectionable contained in from 120 grams to 160 grams of the glucose or grape sugar, *i. e.*, from a quarter to one-third of a pound. It must be borne in mind, further, that the extract which was taken into the stomach must have contained any objectionable mineral, as well as organic substances, present in the glucose employed. Hence the results seem to be final as regards the injurious natures of glucose or grape sugar made from maize.

These experiments extended over a period of only about two months. On the question, therefore, whether any injurious effect would follow the continuous use of this material the committee has no information.

Our experiments have, of course, no direct connection with those of Schmitz, Nessler, and Von Mering, already referred to. These gentlemen experimented upon potato sugar as furnished by manufacturers in Germany. Our conclusions are valid only for maize sugar as furnished by manufacturers in this country.

It should be further remarked that although our experiments show conclusively that the products of fermentation of glucose are not dangerous to health, it does not necessarily follow that beer made by the fermentation of glucose is as good as that made in the usual way. That is a matter which does not fall within the scope of our investigation.

V.—SUMMARY AND CONCLUSION.

The results which have been obtained by the committee, and which have been presented in the foregoing pages, may be briefly summed up as follows:

1st. Starch sugar, as found in commerce, is a mixture in varying proportions of two sugars called dextrose and maltose, and of dextrin, or starch gum. Dextrose was discovered in honey by Lowitz in 1792, and was first prepared from starch by Kirchhoff in 1811. In 1819 Braconnot prepared it from woody fiber. Maltose was first recognized as a distinct sugar by Dubrunfant in 1847, in the product of the action of malt on starch. No dextrose is thus produced, according to O'Sullivan.

2d. The process of making starch sugar consists, 1st, in separating the starch from the corn by soaking, grinding, straining, and settling; and, 2d, in converting the starch into sugar by the action of dilute sulphuric acid, this acid being subsequently removed by the action of chalk. To make the solid "grape sugar" the action is carried further than to make the liquid "glucose." After clarifying, the liquid is concentrated in vacuum pans and is decolorized with bone-black.

3d. The starch-sugar industry in the United States gives employment to 32 factories, having an estimated capital of $5,000,000, consuming about 40,000 bushels of corn per day, and producing grape sugar and glucose of the annual value of nearly $10,000,000. In Germany, in 1881-'82, there were 39 factories of this sort, consuming over 70,000 tons of starch, and producing about 40,000 tons of starch sugar.

4th. Starch sugar is chiefly used in making table sirup, in brewing beer as a substitute for malt, and in adulterating cane sugar. It is also used to replace cane sugar in confectionery, in canning fruits, in making fruit jellies, and in cooking. Artificial honey is made with it, and so, also, is vinegar.

5th. Starch sugar represents one distinct class of sugars, as cane sugar does the other, the former being obtained naturally from the grape, as the latter is from the cane and the beet. Starch sugar—which is a term chemically synonymous with dextrose and glucose—when pure has about three-fifths the sweetening power of cane sugar. By the action of dilute acids both cane sugar and starch yield dextrose. In the case of starch, however, dextrose constitutes the sole final product.

6th. The commercial samples of starch sugar obtained by the committee showed a fairly uniform composition on analysis. The liquid form, or "glucose," contained from 34.3 to 42.8 per cent. of dextrose, from 0 to 19.3 per cent. of maltose, from 29.8 to 45.3 per cent. of dextrin, and from 14.2 to 22.6 per cent. of water. The solid form "grape sugar" gave from 72.0 to 73.4 per cent. of dextrose, from 0 to 3.6 per cent. of maltose, from 4.2 to 9.1 per cent. of dextrin, and from 14.0 to 17.6 per cent. of water. Three specimens of especially prepared "grape sugar" contained 87.1, 93.2, and 99.4 per cent. of dextrose, respectively. The last of these was crystalline anhydrous dextrose.

7th. Of mineral or inorganic constituents, the samples of starch sugar examined contained only minute quantities. The total ash found in the "glucose" was only from 0.325 to 1.060 per cent.; and in the "grape sugars" only from 0.335 to 0.750 per cent. No impurities, either organic or inorganic in character, other than those mentioned were detected in any of the samples examined.

8th. The elaborate experiments upon the fermentation of starch sugar would seem to be final on the question of the healthfulness, not only of glucose itself, but also of the substances produced by the action of a ferment upon it. Large quantities of a concentrated extract from the fermentation, representing from one-third to one-half a pound of starch sugar, were taken internally by the experimenter, and this repeatedly, without the slightest observable effect. This result, rigidly applied, holds, of course, only for those sugars which, like this, are made from the starch of Indian corn or maize.

In conclusion, then, the following facts appear as the result of the present investigation: 1st. That the manufacture of sugar from starch is a long-established industry, scientifically valuable and commercially important. 2d. That the processes which it employs at the present time are unobjectionable in their character, and leave the product uncontaminated. 3d. That the starch sugar thus made and sent into commerce is of exceptional purity and uniformity of composition, and contains no injurious substances. And, 4th, that though having at best only about three-fifths the sweetening power of cane sugar, yet starch sugar is in no way inferior to cane sugar in healthfulness, there being no evidence before the committee that maize starch sugar, either in its normal condition or fermented, has any deleterious effect upon the system, even when taken in large quantities.

All of which is respectfully submitted.

GEORGE F. BARKER,
Chairman.
WILLIAM H. BREWER,
WOLCOTT GIBBS,
CHARLES F. CHANDLER,
IRA REMSEN,
Committee.

APPENDIX 1.

CIRCULAR SENT OUT BY THE COMMITTEE.

BALTIMORE, ——— —, 1882.

SIR: At the request of the Commissioner of Internal Revenue of the United States, the undersigned have been appointed a committee of the National Academy of Sciences, for the purpose of making a scientific investigation of the various products which are obtained from starch, and known as glucose, grape sugar, maltose, &c., and of the processes used in their manufacture.

While giving full weight to the investigations which have already been made, the committee feel that it is desirable for them to reach their conclusions, as far as possible, independently, and hence they have decided to ask the assistance of the manufacturers in getting together the necessary information, and in taking samples of products for examination. As the investigation is in the interests of the manufacturers, as well as of the public, we respectfully request that, as soon as convenient, you will forward to the Secretary answers to the questions to be found on the next page.

It is, of course, understood that, without special permission from you, no use will be made of the information you may give us, except in a general way, and without mention of the name of your firm.

Yours, respectfully,

G. F. BARKER, *Chairman*,
Professor University of Pennsylvania, Philadelphia, Pa.
W. H. BREWER,
Professor Yale College, New Haven, Conn
C. F. CHANDLER,
Professor Columbia College, New York, N. Y.
WOLCOTT GIBBS,
Professor Harvard College, Cambridge, Mass.
IRA REMSEN, *Secretary*,
Professor Johns Hopkins University, Baltimore, Md.

QUESTIONS SENT OUT BY THE COMMITTEE.

1. Please give as full a description as you may care to of the processes used in your factory. (Descriptions of machinery would not be of much use to the committee.)
2. What are the names and general properties of the products which your firm places on the market?
3. Will you give an agent authorized by us the privilege of taking samples of your products at your factory?
4. What information can you furnish regarding the capacity of your establishment, as shown by the consumption of raw material in 1881 and 1882? Is any other material used besides corn?
5. What is the principal use made of your products?
6. Please add the names and addresses of any firms known to you, and not included in the accompanying list.

APPENDIX 2.

The glucose and starch-sugar factories of the United States.

Location of factory.	Name of factory.	Name of firm.	Office of firm.
ILLINOIS.			
*Champaign	Champaign Grape Sugar Company.	Champaign Grape Sugar Company, Mr. Smith, president.	Champaign, Ill.
*Chicago	Eberts'	Eberts'	Chicago, Ill.
*Chicago	Chicago Sugar Refining Company.	Chicago Sugar Refining Company.	Chicago, Ill.
*Danville	Danville Refinery and Starch Works.		Danville, Ill.
*Freeport	Kings Co. Refinery	Veiller, Jayne & Co	Freeport, Ill.
*Geneva	Geneva Grape Sugar Company.	Geneva Grape Sugar Company.	Geneva, Kane County, Ill.
*Gladstone	Gladstone Refinery Sugar Company.	Gladstone Refinery Sugar Company.	Gladstone, Ill.
*Pekin	Richard & Gill	Richard & Gill	Pekin, Ill.
*Peoria	Peoria Grape Sugar Company.	Peoria Grape Sugar Company.	Peoria, Ill.
Peoria	Peoria Sugar Refinery	Peoria Sugar Refinery, C. J. Hamlin, president.	No. 19 West Swan street Buffalo, N. Y.
*Rockford	Rockford Grape Sugar Company.	Rockford Grape Sugar Company.	Rockford, Ill.
*Sagetown			Sagetown, Ill.

*Factories to which the Circular (Appendix 1) was sent. (See page 8.)

The glucose and starch-sugar factories of the United States—Continued.

Location of factory.	Name of factory.	Name of firm.	Office of firm.
*IOWA.			
Davenport	Davenport Glucose Manufacturing Company.	Davenport Glucose Manufacturing Company.	Davenport, Iowa.
*Des Moines	Des Moines Sirup Refinery.	Des Moines Sirup Refinery.	Des Moines, Iowa.
*Iowa City	Iowa City Grape Sugar Company.	Iowa City Grape Sugar Company.	Iowa City, Iowa.
*Marshalltown	Grape Sugar Company	Grape Sugar Company	Marshalltown, Iowa.
KANSAS.			
Atchison			Atchison, Kans.
Leavenworth	Leavenworth Sugar Company.	Leavenworth Sugar Company, C. J. Hamlin, president.	No. 19 West Swan street, Buffalo, N. Y.
MICHIGAN.			
*Detroit	Michigan Sugar Company.	D. H. Howell, Sons & Co., agents.	Agents' office, 107 Wall street, New York.
MISSOURI.			
*Kansas City	Rochester Grape Sugar Company.	Rochester Grape Sugar Company.	Kansas City, Mo.
Saint Joseph	Saint Joseph Refining Company.	Saint Joseph Refining Company.	Saint Joseph, Mo.
*Saint Louis	Saint Louis Sirup Glucose and Grape Sugar Company.	Saint Louis Sirup, Glucose, and Grape Sugar Company.	Saint Louis, Mo.
NEBRASKA.			
Omaha			Omaha, Nebr.
NEW YORK.			
*Buffalo, Scott street and Hamburg Canal.	American Grape Sugar Company.	American Grape Sugar Company, C. J. Hamlin, president.	No. 19 West Swan street, Buffalo, N. Y.
*Buffalo, Court street	Buffalo Grape Sugar Company.	Buffalo Grape Sugar Company, C. J. Hamlin, president.	No. 19 West Swan street, Buffalo, N. Y.
*East Buffalo, Jefferson street, near William.	The Firmenich Sugar Refinery Company.	The Firmenich Sugar Refinery Company.	No. 22 West Seneca street, Buffalo, N. Y.
*Glen Cove, Long Island.	Glen Cove Manufacturing Company.	Glen Cove Manufacturing Company.	298 South street, New York City.
*New York City, 132 King street.	Booth & Edgar's Factory.	Booth & Edgar	100 Wall street, New York City.
421 West Fifteenth street.	Manhattan Sugar Company (limited).	Manhattan Sugar Company (limited).	421 West Fifteenth street, New York City.
OHIO.			
*Tippecanoe City	Grape Sugar Company	Grape Sugar Company	Tippecanoe, Miami County, Ohio.
Toledo			
WEST VIRGINIA.			
Wheeling	Fell's Sirup Factory	Fell, A. C.	Wheeling, W. Va.

* Factories to which the Circular (Appendix 1) was sent. (See page 8.)

In response to this circular very full communications were received from the following manufacturers:

J. A. Cunningham, Danville Refining and Starch Works, Danville, Ill.

George Turner, secretary and treasurer Geneva Grape Sugar Company, Geneva, Ill.

W. H. H. Ammack, superintendent Gladstone Grape Sugar Company, Gladstone, Ill.

Dr. F. H. Kimball, chemist Rockford Grape Sugar Company, Rockford, Ill.

Louis P. Best, superintendent Davenport Glucose Manfacturing Company, Davenport, Iowa.

H. B. Leavens, secretary Des Moines Sirup Refinery, Des Moines, Iowa.

W. J. Allen, superintendent Iowa City Grape Sugar Company, Iowa City, Iowa.

J. D. Hayes, vice-president Michigan Grape Sugar Company, Detroit, Mich.

George B. Emmons, president Saint Louis Sirup, Glucose, and Grape Company, Saint Louis, Mo.

The Firmenich Sugar Refining Company, Buffalo, N. Y.

Harry Hamlin, vice-president Buffalo Grape Sugar Company, Buffalo, N. Y.; vice-president of the American Grape Sugar Company, Buffalo, N. Y.; vice-president of the Peoria Sugar Refining Company, Peoria, Ill.; vice-president of the Leavenworth Sugar Company, Leavenworth, Kans.

Hiram Duryea, vice-president Glen Cove Manufacturing Company, Glen Cove N. Y.

Augustus Talbot, Manhattan Sugar Company (limited), New York.

The Grape Sugar Company, Tippecanoe City, Ohio.

A. C. Fell, Fell's Sirup Factory, Wheeling, W. Va.

Valuable information was also received from the following:

Arno Behr, Ph. D., Chicago, Ill.

Waldron Shapleigh, Freeport, Ill.

Albert L. Colby, Ph. B., inspector New York State board of health.

S. D. Phelps, New York.

Edgar Tucker, New York.

APPENDIX 3.

EXAMINATION OF COMMERCIAL SUGARS WITH REFERENCE TO THEIR ADULTERATION WITH STARCH SUGAR.

A.—*Analyses of sugars purchased in open market.*

Sixteen samples of brown sugars were bought in the open market at various groceries. Four of these were found to contain aboot 30 per cent. of grape sugar. It is impossible to determine with accuracy the amount of grape sugar present in a sample of adulterated cane sugar for the reason that the brown cane sugars always contain invert sugar which gives reactions indentical with those of grape sugar. The amount of invert sugar present varies, but may reach as much as 5 per cent., and perhaps more. If, however, in examining a specimen of cane sugar there should be found evidence of the presence of, say, from 20 to 30 per cent. of a sugar giving the reactions of grape sugar, the conclusion would certainly be justified that the latter had been ad

In our examinations the first test applied in every case was the treatment of the sample with luke-warm water. If no grape sugar is present the sample dissolves up quickly. If it is present in considerable quantity there remains behind for some time undissolved a quantity of matter consisting of white, chalky-looking particles.

For the purpose of estimating the quantity of grape sugar present in the adulterated samples two methods were used:

1. The well-known method of Fehling, with the precautions and modifications suggested by Allihn (Journal für Praktische Chemie, vol. 130, page 46), and

2. The method of Sachsse, modified as directed by Heinrich (Chemisches Centralblatt, 1878, p. 409).

For the Fehling-Allihn method, dissolve 173 grams sodium potassium tartrate and 125 grams potassium hydrate in water, and dilute so as to make 500 c. c. Also dissolve 34.6 grams copper sulphate in water and make up to 500 c. c. Keep the two solutions separate, and only bring them together when needed for immediate use.

For a determination, 30 c. c. of each of the solutions are brought together, and 60 c.c. water added. The whole is then heated to boiling. Twenty-five c. c. of a sugar solution which must not contain more than 1 per cent. sugar, are then added, and the whole heated on a water-bath for fifteen minutes. The precipitate is collected in an asbestos filter, washed with alcohol and ether, and a current of dry air drawn through.

When dry, the suboxide of copper is reduced to copper in a current of hydrogen. The whole filter (tube and asbestos), together with the copper, is now weighed, and the weight of the copper found by deducting the weight of the filter previously taken. The weight of sugar corresponding to the weight of copper found can be taken from Allihn's table (loc. cit., pp. 63–65).

For the preparation of the Sachsse-Heinrich solution, 18 grams pure mercuric iodide, 25 grams potassium iodide, and 10 grams potassium hydrate are dissolved in water, and the volume made up to 1 liter. The proportion of potassium hydrate here used is much smaller than that used by Sachsse, which was 80 grams. A portion of the solution prepared in the above way, boiled for thirty minutes with 20 per cent. solution pure cane sugar, failed to give the slightest evidence of the reduction of the mercuric iodide. Forty c. c of this solution were found by titration with standard solutions of pure grape sugar and invert sugar to correspond to .128 gram dextrose and .119 gram invert sugar.

Twelve of the sixteen samples collected did not contain more than 5 per cent. of sugar having an action in the solutions employed in the examination. Some of the details of the analysis of one of the adulterated samples, and the figures obtained in the analysis of two other adulterated samples, are here given.

Sample 1.—Ten grams of the sample were dissolved in 109 c. c. distilled water. Ten grams of this solution were then diluted up to 100 c. c., so that in the weaker solution there was 1 gram of the substance in 100 c. c. of the solution. The amount of this solution necessary to reduce 40 c. c. of the previously standardized solution of mercury iodide was now determined. It was found to be 39.3 c. c. But 40 c. c. of the mercuric iodide solution are equivalent to 0.128 gram of dextrose (pure grape sugar). Therefore, in 0.393 gram of the sample there is 0.128 gram dextrose—an amount which corresponds to 32.9 per cent. This conclusively shows that the sample contained somewhere in the neighborhood of 30 per cent. of grape sugar.

This result was confirmed by the aid of the Fehling-Allihn method. Ten c. c. of the same sugar solution as that used in the preceding estimation were added to 60 c. c. of Fehling's solution. The cuprous oxide was collected on an asbestos filter, reduced to metallic copper, and weighed. The weight of copper thus found was 0.0633 gram. This corresponds to .03235 gram dextrose (grape sugar), or, in 0.1 gram of the sample there was 0.03235 gram of grape sugar. This is 32.35 per cent. of the whole, while by the Sachsse-Heinrich method the amount found was 32.8 per cent.

In *Sample* 2 the Sachsse-Heinrich method indicated the presence of 33.6 per cent. of dextrose, while the Fehling-Allihn method gave 33.8 per cent.

In *Sample* 3 the former method gave 26.3 per cent. and the latter 26.9 per cent. dextrose.

A fourth sample gave results similar to those just described, and was undoubtedly adulterated.

While the figures given cannot be regarded as accurate, they show beyond a doubt that the samples examined were largely adulterated. Whether the amount of grape sugar present is exactly stated or not, there was certainly present as much as 20 per cent. and probably somewhere between 30 and 40 per cent. If the samples examined had consisted of pure cane sugar mixed with pure grape sugar the figures obtained would have varied only very slightly from the truth. But in fact neither the cane sugar nor the grape sugar was pure, and we cannot tell what allowance to make for the impurities. There may have been as much as 5 per cent. of a reducing sugar, like grape sugar, in the cane sugar originally used. There could hardly have been much more. Subtracting this amount (5 per cent.) from the total found in the first adulterated sample, there remain about 27 per cent. of reducing sugar which must have been intentionally added. But this figure represents only the amount of ***reducing sugar*** added, and not the total quantity of substance added. Now, as has been shown in an earlier part of this report, the commoner grades of commercial grape sugar contain only about 70 to 75 per cent. of reducing sugar, so that in order to add to a cane sugar 25 per cent. of a reducing sugar we should have to add a considerably larger amount of commercial grape sugar, say, about 33 per cent. Hence it appears probable that the adulterated samples examined by us contained about 33 per cent. of grape sugar.

B.—*Extracts from Board of Health Reports.*

[Extract from the Report of A. L. Colby, Ph. B., to the Sanitary Committee of the New York State Board of Health in 1881. Second Annual Report of the Board, p. 604.]

Although, as we have just seen, the sugars of to-day are free from insoluble mineral adulterations, the use of glucose as an adulterant is practiced to a considerable extent. The result of the examination of the 116 samples for the presence of artificial or added grape sugar or glucose is given in the following table:

Grade of sugar.	Number examined.	Unadulterated.	Adulterated with glucose.
Cut loaf	7	7	....
Granulated	4	4	....
"A"	5	5	....
Powdered	33	33	....
Light-brown, "Extra C"	49	46	3
Brown, "C"	10	9	1
Dark-brown, "X"	8	8	....
Total	116	112	4

This table shows that the white sugars are all unadulterated. But the brown sugar (especially light brown coffee sugar "Extra C") is the variety in which this sophistication is practiced. As the table shows, of the sixty-seven samples examined, four were found adulterated, and to a large extent, as may be seen by the following analysis:

No. of sample.	Character of sugar.	Per cent. of added glucose.	Per cent. of total glucose.
705	Brown "C"	22.20	Undetermined.
706	Light brown "Extra C"	21.24	26.522
707	Light brown "Extra C"	29.79	32.834
708	Light brown "Extra C"	33.36	35.878

All colored sugars contain more or less "fruit" or "invert sugar," which is a mixure of equal parts of dextro-glucose and levoglucose. This is produced from the cane sugar in the process of manufacture. The artificial glucose, used as an adulterant, is dextro-glucose made from starch.

These so-called "mixed sugars" are sold in the wholesale market under certain trade names, such as "new process sugar," "Niagara A, B, C," "Harlem B," "Excelsior C," &c., which signify to the purchaser their character. They are, however, usually disposed of in the retail trade as pure sugar. As most of these "mixed sugars" are sent to the country, they are rarely to be found in the hands of retail city grocers.

A review of other recent investigations of sugar proves the general use of glucose as an adulterant. From the six annual reports on the adulteration of food in Canada* the following tabular statement of the results has been compiled:

SUGARS ANALYZED.

Date of report.	Number of sugars analyzed.	Genuine.	Adulterated with glucose.	Doubtful.
First report, 1876	15	12	3	....
Second report, 1877	34	30	4	....
Third report, 1878	42	34	8	....
Fourth report, 1879	101	31	9	11
Fifth report, 1880	55	55	....	....
Sixth report, 1881	63	63	....	....
Total	310	275	24	11

An investigation of seventy-five samples of sugar, made in 1879 by the Massachusetts State Board of Health, Lunacy, and Charity,† shows the presence of an undue excess of glucose in three cases.

The recent investigation of sugars, made by Dr. Charles Smart, under the direction of the National Board of Health,‡ shows the very general use of glucose as an adulterant. "Among forty-seven brown sugars, most of which were furnished by dealers who knew that their samples would be examined, there were found three which contained glucose; while among thirty-eight samples purchased for analysis, no less than nine were thus adulterated. The glucose varied from a small admixture to 30 per cent."

APPENDIX 4.

EXTRACTS FROM THE JOURNAL LITERATURE RELATING TO STARCH SUGAR, CHRONOLOGICALLY ARRANGED.

[Prepared by E. J. HALLOCK, Ph. D.]

KIRCHHOFF'S DISCOVERY OF STARCH SUGAR.

[Prof. John (1812). Schweig. J., IV, III.]

The author learns through Nasse that Kirchhoff was trying to make a cheap gum, and produced sugar instead. From 100 pounds starch, N. & K. got 90 pounds solid grape-like sugar, or 120 pounds of very sweet sirup.

It is a peculiar kind of sugar, resembling grape sugar, but better.

Nitric, hydrochloric, sulphuric, and oxalic acids produce it; but tartaric, acetic (?) and phosphoric do not.

PREPARATION OF STARCH SUGAR.

[Schrader (1812). Schweig. J., IV, p. 108.]

Author repeated Kirchhoff's experiment. The latter employed 1 part acid and 400 of water to 100 of starch, and boiled 36 hours. Schrader used more acid and boiled 9 hours, and got a sweeter product. He compares the operation to the manufacture of ether.

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* Report on the adulteration of food, being supplement No. III to the report of the Department of Inland Revenue.

† First Annual Report State Board of Health, Lunacy, and Charity of Massachusetts, 1879, page 60

‡ National Board of Health Bulletin Supplement No. 6, January 1, 1881.

CONVERSION OF STARCH INTO SUGAR.

[Pfaff (1812), in Schweig. J., V, p. 94.]

Author repeated Kirchhoff's experiment in glass retort, and found no CO_2 or SO_2 evolved, hence the conversion is not oxidation, nor does it resemble germination which yields CO_2. He does not compare it with ether-making, because the circumstances differ. He calls it killing the starch, and compares it to potatoes that get sweet under the influence of cold.

CONVERSION OF STARCH INTO SUGAR.

[Vogel (1812), in Schweiger's J., V, p. 80.]

The author first asserts that no chemist had yet made sugar by chemical means until Kirchhoff, in St. Petersburg, made a gummy and sugary substance by acting on starch with sulphuric acid.

The author repeated Kirchhoff's experiments, using 40 grams of acid in 8 kilograms of water (1-200) for 2 kilograms of starch. He obtained an equal weight of sirup containing varying quantities of sugar and gum. The latter was insoluble in alcohol, but did not form gummic acid when acted on by nitric acid. He believes that the acid withdraws the elements of water from the starch. (See also Gilbert's Ann., XLII, p. 123.)

ON THE SWEETNESS OF STARCH SUGAR.

[Gehlen (1812). Schweig. J., V, p. 42.]

This author repeated Kirchhoff's experiment, and described the product as yellowish, soluble in 1½ parts water; gives a white precipitate with oxalates, none with H_2S $(NH_4)_2S$, KCy, or tincture of galls. Only experience can tell whether it is wholesome, but probably is so (p. 41). Does not form caramel when heated, and melts easily. In sweetening power 2½ or 2¼ equals 1 of cane sugar. Its price must be proportionately lower than cane sugar to compete with it. The sirup irritates the throat like honey, which it closely resembles.

WAS STARCH SUGAR A FRENCH DISCOVERY?

[De Gassicourt (1812), in Schweig. J., V, Beilage; Moniteur, No. 150.]

In 1801 Fourcroy obtained a sugary substance by passing chlorine into a solution of gum, or starch suspended in water.

Parmentier, in his Pharmacopeia, p. 361, says he formed sugar from starch by the action of cream of tartar 30 years ago.

Schweiger adds a note that nearly upsets all this author says.

ACTION OF THE GLUTEN IN CONVERTING STARCH INTO SUGAR.

[Kirchhoff (1814). Schweig. J., XIV, 389. Read in St. Petersb. Acad., Sept. 1, 1812.]

The author deduces the following conclusions from his experiments:

1. Gluten causes the formation of sugar in germinated seed and in the meal which has been soaked in hot water.
2. The starch in germinated grain is unchanged, and is first converted into sugar (at a temperature above 40° R.) by the gluten.
3. The starch in the flour is to be considered as the best material for making alcohol.
4. In germination the gluten acquires the power of saccharifying more starch than the grain contains.
5. The production of sugar in germinated seeds is a chemical process and not the result of vegetation.
6. In wort the starch is in the sweet form, and infusion of galls does not affect it.

DECOMPOSITION OF STARCH BY WATER.

[Saussure (1819) Ann. Chim. Aug., 1819; Schweig. J., XXVII, 320.]

When starch and water are exposed to a temperature of 20 or 25° C., with or without access of air, there are formed—

1. A kind of sugar similar to that made by the action of acid.
2. A kind of gum similar to roasted starch.
3. A substance here called Amidin between gum and starch in properties.
4. A substance as insoluble in boiling water and several acids as woody fiber, but is blued by iodine.

Also other products.

SUGAR FROM OLD LINEN.

[Braconnot (1819). Ann. Chim. Phys. Oct., 1819, p. 172; Schweiger's J., XXVII, 337.]

Twenty-four grams old dried linen was first converted into gum by 34 grams sulphuric acid, diluted, the unchanged fiber (3.6 grams) filtered out, then boiled two hours, and saturated with carbonate of lime. Basic acetate of lead gave no precipitate. The solution was evaporated and heated until it smelled of burnt sugar. Yield was 23.3 grams from 20.4 of linen. It was diluted to a sirup, and in twenty-four hours began to crystallize. It has a pleasant, pure, and rather cooling taste. It is capable of fermentation.

CONVERSION OF CANE SUGAR BY PECTINE.

[Le Roy (1832). Ann. Ch. Pharm., VIII, 297; J. de Chim. Med., VIII, 597.]

Author boiled the juice of ripe currants, apricots, strawberries, &c., before fermentation, with 1¼ parts of cane sugar; in a few months the sugar was all converted into grape sugar. This was not the case when the juice had fermented beforehand.

Chevallier had already made a similar observation.

Le Roy's experiments go to prove that the inversion is caused by the pectine.

PRODUCTS FORMED FROM STARCH BY DIASTASE.

[Payen & Persoz (1833). Ann. Chim. Phys. (2), LIII, 73.]

The starch is entirely changed into two bodies, an uncrystallizable sugar and a gum, the sum of whose weights equals that of the starch.

BEER FROM STARCH SUGAR.

[Lampadius (1833). J. pr. Ch. XVI, 375; Pharm. Centrl., 1833, 351.]

Author prepared a very good beer from starch sugar, with extract of hops, yeast, and some white of egg. After lying three weeks it was clear, sparkling, and of very pleasant flavor.

PREPARATION BY MEANS OF DIASTASE.

[W. A. Lampadius (1834), in J. pr. Ch. II, 457.]

Four pounds potato starch and 24 pounds water boiled to a paste in a tinned copper cylinder. Kept ten hours at 42–47° R. after putting in half pound of barley malt coarsely ground in a coffee-mill. No change, as the malt was five weeks old. With fresh malt the paste became a thin liquid in 10 minutes but not very sweet, but sweetness increased for eight hours. No blue color with starch. Yield of 4 pounds 13 loth of transparent sirup, sp. gr. 1.280. In taste it differs somewhat from that made with sulphuric acid.

SUGAR OBTAINED FROM STARCH BY MEANS OF DIASTASE.

[Guerin-Varry (1835). Ann. Chim. Phys. (2) LX, 54.]

It is white, odorless, less sweet than cane sugar, crystallizes in cauliflower crystals sp. gr. 1.3861. Heated for an hour at 100° loses 9.8 per cent. of its weight of water.

At 23°.5 63¼ parts dissolve in 100 of water; is a little less soluble than grape sugar, 100 parts yield 42.288 of CO_2 and 44.28 of alcohol. That made by the action of acids has the same composition as that made by diastase, and as grape sugar.

COMPOSITION AND PREPARATION OF STARCH SUGAR.

[C. Brunner (1835) Pogg. Ann., XXXIV, 319; Ann. Ch. Pharm. XIV, 303.]

Author refers to the contradictory views of Saussure and Converchel; also Guerin, Guilbourt, Raspail, Biot and Persoz.

Brunner's experiments gave for the composition of pure potato starch—

	I.	II.	III.	Average.
C	44. 373	44. 672	43. 242	44. 095
H	6. 316	6. 360	6. 756	6. 477
O	49. 311	48. 968	50. 002	49. 428

From 100 parts of this starch he obtained 106.82, 108.82, 106.238, 106.239, 106.711; average, 107.01 of dry sugar. He then made the Na Cl compound and found an average of 13.522 per cent. Na Cl. Calloud found 8.3 per cent. in that made from urine-sugar 25 per cent. in that from grape sugar.

MANUFACTURE OF STARCH SUGAR.

[Bouchardat (1836), in J. pr. Ch. VII, 83.]

1. It is better to use but little acid and let it act a long time, until alcohol gives no precipitate.
2. Must saturate at once when done.
3. Steam better than open fire.
4. Avoid too much lime, as it blackens and destroys the sugar. The best char is that from Prussian-blue factories.

MANNA SUGAR IN STARCH SUGAR.

[Fremy (1836), in L'Institut; Abst. in J. pr. Ch VIII, 197.]

Fremy prepared the starch sugar with care in the usual manner, crystallized it once, and treated it with alcohol.

From the solution he obtained manna sugar in crystals, hence it is not a product of fermentation, but being infermentescible remains in the fermented sirup.

MANNITE FROM STARCH SUGAR.

[Fremy (1836) Inst. Pharm. Centrl., 1836, 686.]

Author obtained mannite by treating a starch sugar (made with sulphuric acid) with alcohol. Hence it is present in the starch sugar and not formed from it by fermentation. Being incapable of fermenting, it remains unchanged in fermented liquors.

COST AND VALUE OF STARCH SUGAR.

[J. pr. Ch. XI, 185, 1837.]

A "wispel" of potatoes makes 500 pounds of green starch; 250 pounds of this starch will make 1 hundred-weight of dry sugar, worth, in Berlin, 13 or 14 thalers ($10.50).

The waste is used for fodder, and covers the expense of fuel, labor, &c.

Starch sugar is used by bakers and brewers, and to improve wines, to make artificial wines and liquors, and the cost of manufacture is 4 groschen (3 pfennigs) per 100 pounds of patatoes. 100 pounds of potatoes are worth 16 to 18 groschen (40 to 45 cents).

FORMULA FOR STARCH SUGAR.

[Peligot (1838). C. R., VI, 232; J. pr. Ch. XIII, p. 380; J. pr. Ch. XIV, p. 84.]

He made a barium, lead and Na Cl compound and deduced these formulas:

Crystallized sugar	$C_{48}H_{42}O_{21}, 7H_2O$
Sugar dried at 100°	$C_{48}H_{42}O_{21}, 3H_2O$
Saccharate of baryta	$C_{48}H_{42}O_{21}, 3BaO, 7H_2O$
Saccharate of lead	$C_{48}H_{42}O_{21}, 6PbO$
Salt and sugar	$C_{48}H_{42}O_{21}, Cl_2Na, 5H_2O$
Salt and sugar, dried at 130°	$C_{48}H_{42}O_{21}, Cl_2Na, 3H_2O$

DECOMPOSITION OF GRAPE SUGAR BY PEROXIDE OF LEAD.

[A. Stürenburg (1839). Ann. Ch. Pharm., XXIX, 291.]

The oxide of lead was stirred into water and heated to boiling, then the sugar added until the brown color had nearly disappeared. Carbonic acid was evolved, and an odor of formic acid noticed; carbonate of lead alone remained.

One atom sugar forms 4 atoms water.
One atom sugar forms 2 atoms CO_2.
One atom sugar forms 2 atoms formic acid.
One atom sugar forms 8 atoms of the three.

Cane sugar suffered a similar change, but more slowly.

ACTION OF CONCENTRATED SULPHURIC ACID ON STARCH SUGAR.

[Peligot (1839). Ann. Ch. Pharm., XXX, 78.]

If 1 part crystallized starch sugar is melted in a water bath and 1¼ part concentrated sulphuric acid added slowly with cooling, an acid is formed which forms with oxide of lead a white salt. Author calls it saccharo-sulphuric acid (Zuckerschwefelsaure).

DIGESTION OF STARCH.

[J. Vogel (1841). Valentine's Rep., 1841, 293; Pharm. Centrl. 1842, 48.]

The author thinks that the fact observed by Leuchs and confirmed by Huenefeld, that saliva is able to convert starch into sugar, is of little consequence in digestion, because unchanged starch is often present in the stomachs of men and animals.

FERMENTABILITY OF THE SUGARS.

[H. Rose (1841.) Pogg. Ann. LII, 293; Ann. Ch. Pharm., XL, 324.]

If equal weights of cane and grape sugar are dissolved in equal parts of distilled water, and small but equal quantities of yeast added, at 20° C., the former begins to ferment at once, and in a few days it is finished. The latter can be kept for months at 25° or 30°. To bring both into equal fermentation seven or eight times as much yeast must be put in the cane sugar solution as the excess is required to convert it into grape sugar. Grape sugar is the only directly fermentescible substance, and cane sugar is more easily converted into grape sugar than any other vegetable substance, and this is best accomplished by tartaric acid or argol.

OPTICAL PROPERTIES OF SUGARS.

[Ventzke (1842). J. pr. Ch. XV, 65.]

Describes his polarizing apparatus (illustr.) and its uses.

Fruit sugar, uncrystallizable sugar, always turns to the left. It is found in sweet fruits (grapes), and honey is formed from other sugars by acids, from cane sugar (and probably milk sugar) by the action of ferments.

Grape sugar, in urine, in solid honey, action of acid or diastase on amylon, acids on cane sugar, in many sweet fruits.

A table is given for ten sugars, showing the rotation in tube 234 millimeters long.

INFLUENCE OF WATER AND HEAT ON SUGAR.

[Soubeiran (1842). Jour de Pharm., 1842, pp. 1 and 89; J. pr. Chem., XXVII, p. 298.]

His experiments proved the stability of crystallized grape sugar under the influence of water and heat and of acetic acid; but it is easily decomposed by alkalies.

Uncrystallizable (inverted) sugar is decomposed by acetic acid and by alkali.

Optical tests employed.

GLUCOSE FERMENTATION.

[Bouchardat (1846). Ann. Chim. Phys; Ann. Ch. Pharm., LIX, 80.]

Diastase acts most powefully on starch paste, but is not the only thing which will convert starch into dextrin and glucose. He gives a list of these substances, such as yeast, germinated grain, membranes, &c.

Effect of reagents on the action of diastase: Nitric, sulphuric, phosphoric, hydrochloric, oxalic, tartaric and citric prevent the action of diastase entirely. Fixed alkalies also prevent it; also chlorine and bromine. Sulphate and acetate of copper and corrosive sublimate prevent; calomel not. Neutral chlorides of calcium, barium, strontium, and ammonium do not. Sulphate, acetate, borate, phosphate, and iodide slightly check it. Alkaloids have little influence. Alcohol, ether, essential oils, and creosote have no effect.

CONVERSION OF CANE SUGAR INTO A SUBSTANCE ISOMERIC WITH CELLULOSE.

[Tilley & Maclagan, Phil. Mag., 1846; Ann. Ch. Pharm., LX, 263.]

When the mixture of sugar, water, tartaric acid, and etherial oils used for lemonade stands a long time it forms a thick, sticky substance of the same composition as cellulose.

ON GLUCOSE (MALTOSE).

[Dubrunfaut (1847). Ann. Chim. Phys., XXI, 178; J. pr. Ch., XLII, p., 425, 1847.]

Dumas gives this name to different sugar-like products that crystallize in worts. Those from fruit, honey, or diabetic urine, or made by the action of acid on starch or wood fiber, are identical.

When made by the action of malt on starch it has a greater rotary power. It seems to crystallize in rhombohedra, is less soluble in alcohol, and less affected by alkalies. It is converted into glucose by boiling with acids.

GLUCOSE.

[Dubrunfaut (1847). Ann. Chim. Phys., 1847, p. 1879; Ding. J., CVII, 358.]

Glucose made by action of malt on starch is less soluble than that from grapes, and less affected by boiling with water or alkali. Its rotatory power is three times as great, but changes with the time. If boiled long enough with sulphuric acid, forms a sugar identical with grape sugar. It is the first product of the action of acids on starch and the end product of the action of glutinous nitrogenous materials.

Jacquelin and Biot's starch sugar with double rotation is a mixture of two kinds of glucose with single and triple rotation.

DETECTION OF STARCH SUGAR IN CANE SUGAR.

[Chevallier (1848). J. Chim. Med., Mar. 1848; Ding. J., CVIII, 319.]

20.0 grams water.
10.0 grams sugar.
0.5 grams caustic potash.

Heat in a porcelain dish on the open fire.

Cane sugar turns greenish-yellow.

Mixed sugar turns coffee brown.

DETECTION OF ADULTERATIONS OF SUGAR WITH GLUCOSE.

[Reich (1848). J. pr. Ch., XLIII, p. 71.]

Evaporate and add concentrated H_2SO_4 in slight excess; filter; add $BaCO_3$; filter, and if dilute H_2SO_4 gives a precipitate there was sulpho-saccharic acid formed.

Another test is potassium bichromate; also cobaltic nitrate.

COMPOSITION OF HONEY.

[Soubeiran (1849). J. Pharm. Chim., XVI, p. 252; J. pr. Chem., XLIX, p. 65.]

Honey consists of three kinds of sugar.

The first is krümel sugar.

The second is a liquid sugar, similar to that made by the action of acid on cane sugar, but has nearly twice its rotatory power to the left.

The third can be inverted, but turns light to the right.

INVERT SUGAR, HONEY, AND RAISINS.

[Dubrunfaut (1849). C. R., XXIX, 51; Ding. J., CXII, 387.]

1. Sugar made from cane sugar by acids or ferment is a mixture of equal equivalents of crystallizable grape sugar, $C_{12}H_{12}O_{12}$, and an uncrystallizable sugar of the same composition; rotates to the left, &c.
2. Honey, when fresh, contains varying quantities of cane sugar, all being in the liquid part; it disappears in time under the action of a natural ferment. Characteristic flavor due to substances developed by the alcoholic fermentation. Contains 20 to 30 per cent. glucose. Every honey contains a large quantity of fruit sugar, also an excess of glucose or other dextra-rotatory sugar. Its purgative properties are due to the liquid sugar.
3. The dextro grape sugar on raisins is due to decomposition of the fruit sugar, from fermentation, insects, &c.

ACTION OF WATER ON SUGAR.

[Maumené, C. R., 1854, XXXIX, 422; Ding. J., CXXXV, 59.]

1. The purest cane sugar dissolved in pure water is gradually changed into uncrystallizable sugar, even in the cold.
2. Heat favors this change.
3. Glucose and gum suffer no change.
4. This change takes place in the beet itself.
5. Organic acids do not perceptibly aid it.
6. The effect of the water must be taken into account in the analysis of sirups, &c.
7. Soubeiran's table (C. R. ———), Ding. J., CXIX, p. 146, cannot be employed.
8. The binoxide of potassium is not reliable (Ding. J., CXXV. 292). Dextrin is not always present in commercial glucose.
9. Caustic potash is not infallible, for most sugars are browned by it.
10. Hence it is necessary to measure the actual quantity of crystallizable sugar by crystallizing over lime or sulphuric acid.

FRUIT SUGAR FROM VEGETABLE MATTERS.

[Melsens, Genie ind., 1855, p. 106; Ding. J.. CXXXVIII, 426.]

The author uses leaves, straw, rags, chips, twigs, and residues from breweries, distilleries, &c., by heating in a lead-lined autoclave with water containing 2 to 5 per cent. of acid. Also lets them soak in acidified or alkaline water previous to treatment, *or lets them putrefy,* as in the old way of making paper.

ADULTERATED GLUCOSE.

[L. Gall. Polyt. Notiz., 1856, No. 4; Ding. J., CXXXIX, 468.]

Author says that there was in the market a sort of grape sugar, sold at 8 thalers per cwt., for "improving wine," which imparts to the wine a bad taste.

Test.—Dissolve in warm water; then cover the vessel and boil; on removing the cover a vile odor is noticed. Pure glucose gives no odor.

ON THE USE OF THE WORD GLUCOSE.

[Biot (1856), in C. R., XLII, 351; J. pr. Ch., LXVIII, 429.]

This word was originally used for starch sugar only, and should not be applied to all solid sugars, or to subjects differing in chemical, physical, and crystallographic properties. Three different sugars made from starch:

No. 1, rotatory power of 51.13 right.
No. 2, rotatory power of 1.54 right.
No. 3, rotatory power of 100.57 right.

CHANGE IN THE ROTATORY POWER OF GLUCOSE.

[Bechamp (1856). C. R. XLII, p. 896, 1856, J. pr. Ch. LXIX. 433.]

The change is attributed to a gradual conversion of crystallized into uncrystallizable sugar.

He also concludes that there are two definite modifications of anhydrous starch sugar, $C_{12} H_{12} O_{12}$. One of these melts easily at 100°, and has a rotation of nearly 57°.3 which is unchangeable. The other does not melt at 100°, has a variable rotation which tends to approach (with the time) 57°.3.

CONVERSION OF MANNITE AND OF GLYCERIN INTO A TRUE SUGAR.

[Berthelot (1857). C. R. XLIV, 1002, J. pr. Ch. LXXI, 507.]

Various substances will produce this change, but only one will do so regularly at all times, viz, the membrane of a testicle (man, cock, dog, or stallion).

Formation of *Pencillium glaucum* is a hindrance.

ACTION OF WATER ON CANE SUGAR.

[Bechamp (1859). C. R., XLVI, p. 44; Ding. J., CXLIX, 207.]

A solution of cane sugar in pure water kept 17 months and changed from 22° to 1°.5 in rotatory power, and mold formed. When creosote or corrosive sublimate were added, it lost none of its rotatory power. A solution in boiled distilled water, protected from the air, sufferered no change.

Cold water alone cannot invert cane sugar; the conversion is due to a sort of fermentation.

PREPARATION AND PROPERTIES OF GLUCOSE.

[E. F. Anthon (1859). Ding. J., CLI, 213.]

1. *Percentage of water.*—Anhydrous glucose dried at 100° C., is $C_{12} H_{12} O_{12}$. Ordinary air dried (krümelige) is $C_{12} H_{12} O_{12} + 2 H O$. Author has prepared hard crystallized glucose, which contains $C_{12} H_{12} O_{12} + H O$.

2. *Solubility in water.*—One hundred parts of water dissolves 81.68 parts of the anhydrous sugar at 15° C; or 89.36 parts of the sugar with one molecule water; or 97.85 parts of the sugar with two molecules water of crystallization.

3. *Action of acid on starch.*—Not all the starch has been converted into glucose when the iodine and alcohol tests give no reaction; that is no time when there is nothing but grape sugar in solution.

4. *On the purity of commercial grape sugar and its tests.*—Author determined percentage of foreign matter by the specific gravity of the saturated solutions and gives table.

GRAPE SUGAR FROM WOODY FIBER AND CELLULOSE.

[J. Pelonse, C. R., Feb. (1859). Ding. J., CLI, 394.]

Author found that when wood fiber is boiled a long time in water acidified with hydrochloric or sulphuric acid it is converted into sugar. Paper, old linen, sawdust, etc., are also converted into sugar.

SUGAR FROM GLYCOGEN OF THE LIVER.

[Berthelot & De Luca (1859). C. R. XLIX, 213, J. pr. Ch. LXXXI, 188.]

The sugar was made by the action of dilute H Cl on glycogen from a rabbit's liver. It was combined with Na Cl to form $2\ C_{12}\ H_{12}\ O_{12}\ 2\ H\ O\ Na\ Cl$ which is identical with that which grape sugar forms.

ON THE CONVERSION OF STARCH INTO GRAPE SUGAR AND DEXTRIN.

[F. Musculus (1860). Ann. Chim. Phys., 203, Ding. J., CLVIII, 424.]

1. Diastase has no action on dextrin.
2. Grape sugar and dextrin appear simultaneously and in constant proportions. 1 : 2.
3. Dilute acid acts like diastase.
4. Here too dextrin and sugar both appear together.

CONVERSION OF AMYLACEOUS SUBSTANCES INTO GLUCOSE AND DEXTRIN.

[F. Musculus (1860). C. R., L., 785, J. pr. Ch. LXXXV, 243.]

Author does not think the starch is first converted by dilute acid into dextrin and then hydrated to form glucose.

1. Diastase does not act on dextrin.
2. Glucose and dextrin appear simultaneously and always in the same relative proportions, 2 : 1.
3. At first diastase acts like dilute acid, but its action continues after the starch has disappeared, but acts very slowly then.
4. Dextrin and glucose appear in the same proportions whether diastase or glucose is used.

1. After iodine produces no blue color, and alcohol no precipitate, there is still unfermentable dextrin present in considerable amount.
2. One minute's boiling with acid has no effect on dextrin, but inverts all the cane sugar.
3. A large quantity of starch passes into beer in the form of dextrin.
4. There is great loss in making alcohol from grain by use of diastase = two-thirds loss.

CONVERSION OF STARCH INTO SUGAR.

[T. Musculus (1860). C. R. LIV., 194; Ding. J., CLXIV, 150; Reply to Payen in C. R. LIII, 1217.]

Under the influence of sulphuric acid starch splits up into dextrine and sugar, absorbing water, just as fats take up water and split into glycerine and fatty acids.

All glycosides do the same.

SOLUBILITY OF PURE GRAPE SUGAR IN ALCOHOL.

[E. F. Anthon (1860). Ding. J. CLV, 386.]

The sugar was perfectly pure and contained but 0.2 per cent of water. At 14° R. = 17 ½° C. one part of sugar dissolves in—

50.54 parts alcohol of	0.837
11.34 parts alcohol of	0.980
5.25 parts alcohol of	0.910
2.07 parts alcohol of	0.950

The solubility is not proportional to the amount of water in the alcohol.

At the boiling point—

100 parts alcohol 0.837 dissolves 21.7 sugar.
100 parts alcohol 0.880 dissolves 136.7 sugar.
1 part sugar dissolves in 4.6 of alcohol at 0.837
1 part sugar dissolves in 0.73 of alcohol at 0.880.

After standing standing six days 2.9 parts sugar were held in solution by 100 of alcohol of 0.837 and 12.4 in solution by 100 of alcohol of 0.880.

ON THE SUGAR IN ACID FRUITS.

[H. Buignet (1860). C. R. LI, 894; J. pr. Ch. LXXXVI, 493.]

Cane sugar is usually present in acid fruits, and during the ripening is gradually inverted. In ripe fruits there is either a variable mixture, as in pine apples, apricots, peaches, apples, pears, etc., or it consists entirely of invert sugar, as in figs, currants, and grapes. The cause of difference does not depend on the acidity, but seems to result from a nitrogenous body that acts like a ferment.

PRODUCTION OF DEXTRIN AND GLUCOSE FROM STARCH.

[A Payen (1861). C. R. LIII, 1217; Ding. J. CLXIV, 144.]

1. Author obtained 51 to 83.6 per cent. glucose in three and one-half to five hours with 3 per cent. sulphuric acid.
2. Obtained 34 per cent. sugar from commercial dextrin under like conditions.
3. Hydrochloric acid more active than sulphuric producing 62¼ to 85½ per cent. glucose.
4. Fiber of wood yields glucose (hence alcohol) and a fiber suitable for paper, when treated with hydrochloric acid.
5. After the glucose had been removed from a mixture of the same with dextrin, the latter was easily saccharified by diastase.
6. Beer yeast will not ferment dextrin.
7. Starch paste yielded 52.7 per cent. sugar with diastase—not 87.9.
8. When the maximum yield is obtained the sirup will not crystallize.
9. Starch cannot be converted into dextrin by diastase without forming sugar.
10. Diastase will act below 10°.5 or zero C.
11. Found 0.31 per cent. gypsum in sirup, 0.50 in glucose sugar.

ACTION OF OZONE ON GLUCOSE.

[Gorup-Besanez (1863). Ann. Ch. Pharm, CXXV, 211.]

A solution of grape sugar is not perceptibly changed by ozone until potash or soda, or even carbonate of soda, is added. When the action is ended nothing remains but carbonic acid and formic acid.

Cane sugar is oxidized far more slowly in alkaline solution, but yields the same products.

ACTION OF NITRIC ACID ON LEVOGLUCOSE.

[Hornemann (1863). J. pr. Ch. LXXXIX, 301.]

The pure levoglucose was made from inulin by long boiling in dilute nitric acid. This sugar was purified, and polarized strongly to the left.

After acting on it with nitric acid sp. gr. 1.40 it was entirely converted into racemic acid (traubensäure) which is inactive.

ACTION OF DIASTASE ON STARCH.

[A. Payen (1865). Ann. Chim. Phys., 1865, p. 286, Ding. J. CLXXVIII, 69.]

1. Author has proved that diastase acts on dextrin and is able to partially convert it into grape sugar (krümel).

2. Diastase acting on starch can produce dextrin and grape sugar in varying proportions within the limits of 17 to 50 per cent. or more of sugar in the total product.

3. In making alcohol from grain, all of the starch excepting a few per cent. is gradually converted into sugar and alcohol.

ACTION OF WATER AND NEUTRAL SALT SOLUTIONS ON CANE SUGAR.

[W. L. Classen (1868). J. pr. Ch. CIII., 449.]

1. Cane sugar is gradually changed into glucose by pure water at ordinary temperatures without perceptible mold.
2. Some salts like gypsum, potassium nitrate, &c., prevent this inversion; sulphate of magnesia retards.
3. If left in contact with these salts for several days, then heated to 70° R. a few hours, rapid inversion occurs.
4. If the heating to 70° is done as soon as they are mixed this inversion does not take place, except with gypsum.
5. Experiments can only last a few days as it begins to mold.

His results contradict those of Bechamp regarding the action of pure water.

MALTINE.

[Dubrunfaut (1868). Les Mondes, XVI, 317, Ding. J., CLXXXVII, 491.]

Author applies this name to the active substance precipitated from malt extract by tannin.

It is more active than diastase.

Malt contains 1 per cent. of this substance.

It is nitrogenous like albuminoids, rotates light to the left, and is injured by heat and chemicals.

It is precipitated by 87 to 97 per cent. alcohol.

It is best prepared by extracting the malt cold, or at 30° C., with four or five parts of water, repeat, then add sumach, tanning liquid, or other astringent.

Press in linen bags.

WHY DILUTE SUGAR SOLUTIONS FERMENT BETTER THAN CONCENTRATED ONES.

[J. Wiesner (1869). J. pr. Ch. CVI, 252.]

The rapid withdrawal of water from yeast cells kills all except the younger, undeveloped cells. The effect of very concentrated solutions is to withdraw water from the cells and injure them.

The activity of the yeast depends on the imbibition of water by the protoplasm of the cell and is in inverse proportion to the concentration of the sugar solution.

PROPORTIONS OF LEVULOSE AND DEXTROSE IN INVERTED SUGARS.

[Maumené C. R. (1869) LXIX, 1008; J. pr. Ch. CVIII, 315.]

Author found 12.14 per cent. dextrose, 87.86 per cent. levulose; total 100.

The two were separated by combining the dextrose with sodium chloride and evaporating until it crystallized. Can also be separated by spreading the invert sugar that has been dried at 100° C., on a plate of gypsum.

Author does not think this dextrose identical with that from urine.

ESTIMATION OF GLUCOSE, ETC.

[C. H. Gill (1871). Berl. Ber. IV, 283.]

Basic acetate of lead when used to decolorize the liquid has a perceptible effect on the rotatory power of the levulose, but not of dextrose.

PRODUCTION OF LACTIC ACID FROM SUGAR WITHOUT FERMENTATION.

[Hoppe-Seyler (1871). Berl. Ber. IV, p. 346.]

One pound of grape sugar and one-half liter caustic soda sp. gr. 1.34, diluted with one-half liter water, heated in a large retort to 96°. Violent reaction set in and temperature rose to 116°, without evolution of gas. The product contained lactic acid.

CONVERSION OF GLUCOSE INTO DEXTRIN.

[Musculus (1872). Berl. Ber. V, 648.]

If grape sugar is dissolved in cooled, concentrated sulphuric acid, then alcohol added and left in a cool place, a white substance slowly separates, which exhibits the properties of dextrin, but has double the rotatory power of grape sugar.

ACTION OF SALIVA ON STARCH.

[H. A. Smith (1873). Sugar Cane, V, 448.]

Author's experiments prove that the saliva of an infant, four or five months old, has no action whatever on insufficiently cooked arrow root, but healthy adult secretion has considerable transforming power but the sugar is carried into lactic acid.

Healthy adult saliva entirely transforms well boiled starch in the shortest space of time, while infant saliva causes no change for ten minutes.

Infants can only transform 12 per cent. of starchy food in two hours, and even this is changed into injurious lactic acid.

MALTOSE.

[E. Schulze (1874). Berl. Ber. VII, 1048.]

The author's results resemble those of O'Sullivan. The diastase was precipitated from an aqueous extract of malt by alcohol, and mixed with starch paste at 60°. The saccharine liquid was evaporated to small volume and alcohol added. The precipitate resembles dextrin. The solution was decanted, evaporated to a sirup, and boiled with strong alcohol. When cold the clear solution was poured off and allowed to evaporate over sulphuric acid. It separated as a syrup, but afterwards turned to a mass of crystals.

A SUBSTANCE ISOMERIC WITH SACCHAROSE.

[Gautier (1874). Bull. Soc. Ch. (2) XXII, 145; Berl. Ber. VII, 1549.]

A new substance incapable of fermentation ($C_{11}H_{22}O_{11}$), made by the action of gaseous hydrochloric acid upon a cooled alcohol solution of grape sugar. It is a white substance resembling dextrin, of bitter taste, soluble in water and alcohol, dextrorotatory, and reduces copper solutions.

Heated with water to 160° forms asugar, $C_6H_{12}O_6$ that will not ferment, but reduces Fehling's solution.

CONVERSION OF GLUCOSE INTO LACTIC ACID.

[Maly (1874). Berl. Ber. VII, 1567.]

When a dilute solution of cane, grape or milk sugar, or dextrin is kept at 20 to 40° C., and chopped mucous membrane of swine stomach added, lactic acid is formed, and by neutralizing it from time to time, taking care never to made it alkaline, acid will continue to form as long as any sugar remains. It was identical with lactic acid from fermentation, but contained some sarco or para lactic acid. The proportions varied. It is attributed to an organized ferment in the dead tissue. Living stomachs he says, cannot convert carbo-hydrates into lactic acid.

CONVERSION OF SUGAR INTO LACTIC ACID.

[Gay-Lussac (1874). C. R. Ding. Jour. LXXIV, 80.]

Author refers to Fremy's preparation of lactic acid by means of the membrane of a calf's stomach, and says it seemed to be a purely organic action. Lactic acid is produced in large quantity when sugar is in contact with a large quantity of nitrogenous organic matter at a temperature of 30 or 40° C. Lactic acid is often formed when a vegetable substance is in contact with an animal one.

INVERT SUGAR.

[Maumené (1875). Berl. Ber. VIII, 698.]

Author thinks that invert sugar is a mixture of glucose with a levulo-rotatory sugar which he calls chylariose and a neutral or inactive sugar. The relative proportions vary with the conditions of inversion and other treatment.

UNFERMENTIBLE BODY IN GRAPE SUGAR.

[Neubauer (1875). Berl. Ber. VIII, 1285.]

An average of thirteen analyses of commercial grape sugars showed 18 to 20 per cent. of a substance that does not ferment and rotates more strongly to the right than pure grape sugar. It is not dextrin, but an unknown body between sugar and dextrin.

After fermenting a 10 per cent. solution of grape sugar with fresh beer-yeast filtering and evaporating, a brown sirup remains having a repulsive taste.

ACTION OF SALIVA ON STARCHES.

Leuberg and Georgiewsky (1876). Berl. Ber. IX, 76.]

Other circumstances being the same, it takes less time to convert potato starch into sugar than cornmeal, rice, or wheat starch. Soluble starch is like potato starch.

INACTIVE GLUCOSE.

[Müntz (1876). Berl. Ber. IX, 351.]

Author found in sugar cane that had been kept a long time an uncrystallizable glucose that was inactive toward light. It ferments slowly. Also found mannite.

DEXTRIN IN COMMERCIAL STARCH SIRUPS.

[Fr. Anthon (1876). Ding. J., CCXIX, 437.]

A sample of Bohemian sirup consisted of—	Per cent.
Grape sugar	48.3
Levulose sugar	6.2
Dextrin	25.5
Water	20.0

A French sirup consisted of—	
Grape sugar	30.1
Levulose sugar	5.0
Dextrin	48.0
Water	16.9

A German sirup contained no dextrin and 50 per cent. sugar.

ACTION OF DIASTASE AND DILUTE SULPHURIC ACID ON STARCH.

[Musculus and Gruber (1879). C. R. LXXXIX, p. 1459; Berl. Ber. XII, 287.]

Substances formed are as follows:

Soluble starch; red with I .... rotat. $\alpha = 218°$; red $= +$ 6

Erythrodextrine; red with I ....

Achroodextrine α, colorless I .... rotat. $\alpha = 210°$; red $=$ 12

Achroodextrine β	rotat. $\alpha = 190°$; red =	12
Achroodextrine γ	rotat. $\alpha = 150°$; red =	28
Maltose, $C_{12} H_{22} O_{11} + H_2 O$	rotat. $\alpha = 150°$; red =	66
Glycose, $C_6 H_{12} O_6 + H_2 O$	rotat. $\alpha = 56°$; red =	100

NATURE OF THE INACTIVE GLUCOSES IN CRUDE CANE SUGAR AND MOLASSES.

[Gayon (1879). C. R. LXXXVI, 407; Berl. Ber. XII, 371.]

If pure *Mucor circinelloides* is put in a liquid containing cane sugar, and a mixture of glucose and levulose in such proportions as to neutralize each other, so that the rotation is due to the cane sugar, the rotatory power will decrease gradually (inversion) to a certain point, and then increase to the original value. In the fermentation of invert sugar the glucose is destroyed before the levulose. Gayon added this mucor to cane sugar containing inactive glucose, and observed the same effect, showing the inactive glucose has split into dextro and levulo-glucose.

CAUSES OF THE INVERSION OF CANE SUGAR AND DECOMPOSITION OF GLUCOSE.

[Durin (1879). C. R. LXXXVI, 754; Berl. Ber. XII, 871.]

There are three factors that effect the partial change of cane sugar in glucose, viz, temperature, quality of the water and of the air.

If solutions of pure sugar and of sugar with 2, 3, 8 to 60 per cent. glucose are exposed for 30 or 40 hours to a temperature of 70° or 75°, while the alkalinity is maintained by the addition of a thousandth part of potassic hydrate, none of the sugar is converted into glucose. If the solution is kept at this temperature for 75 to 114 hours, the alkalinity disappears, and inversion begins. The optical activity of the glucose solutions is decreased and the alcoholic fermentation is slower and less perfect.

CONVERSION OF STARCH INTO SUGAR BY DIASTASE AND CARBONIC OXIDE.

[Baswitz (1879). Berl. Ber. XII, p. 1827.]

Some kinds of starch cannot be converted into sugar by diastase without the aid of carbonic acid, but other kinds can. Probably the latter are less pure than the former, the impurity supplying the place of the carbonic acid.

Pressure has no effect.

Best temperature is between 45° and 55° (near 50°). Above 60° very little sugar is formed; at low temperature the sugar forms more slowly, but finally reaches the same quantity.

Concentration.—More sugar is formed when more concentrated, but not a larger percentage referred to the quantity of starch.

MALTO-DEXTRIN.

[Herzfeld (1879). Berl. Ber. XII, 2120.]

Author found that when diastase acts on starch the best results are obtained below 65° C. Above that point there is, in addition to maltose, another substance formed which dissolves in weak alcohol but is not crystallizable. Rotatory power $\alpha = 173.4$ to 169.9. He calls it malto-dextrin. He made the acetyl compound.

SUGAR FROM STARCH.

[Allihn (1880). J. pr. Ch. XXII, p. 46; Berl. Ber. XIII, 1761.]

The conversion is more rapid and more complete the stronger the acid, the longer it acts, and the higher the temperature. Up to 40 or 50 per cent. the conversion is portional to the time, but afterwards slower. Maximum yield 94.5 per cent.

ANHYDROUS DEXTROSE.

[Behr. (1882). Berl. Ber., XV, 1104.]

Shows that when the solidification of the concentrated sirup is produced by dropping in fragments of anhydrous dextrose instead of the hydrate ordinarily used, the resulting mass is crystalline and consists solely of anhydrous dextrose. For the best result the solution should not contain more than 12 to 15 per cent. of water, and the dextrose present should constitute 85 per cent. of the total solid matter. The temperature should be from 30° to 35° C. If the sirup contain as much as 98 per cent. dextrose the anhydrous product often separates spontaneously. When freed from sirup by the centrifugal, anhydrous dextrose resembles cut sugar closely, its sweetening power being to that of cane-sugar as 1:1⅔.

REPORT ON GLUCOSE—Continued.

APPENDIX 5.

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[Prepared by E. J. HALLOCK, Ph. D.]

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1846	Chevallier	Detection of starch sugar by caustic potash.	J. Chim. Med., 1846; Dingl. J., CIII, 399.
1846	Clerget	Estimation of sugar in molasses with Soleil's polariscope.	C. R. XXII, 1138; Dingl. J., CII, 311.
1846	do	Optical analysis of sugars	Bull. Soc. d'Enc., 1846, 549; Dingl. J., CIV, 344; C. R., XXIII, 100, 256, 805.
1846	Dubrunfaut	Effect of temperature on the rotatory powers of sugars.	A. c. p. (3), XVIII, 99; C. R., XXIII, 38; Dingl. J., CII, 304.
1846	Maclagan & Tilley	Conversion of cane sugar into a substance isomeric with cellulose.	A. C, P., LX, 263.
1846	Peligot	Estimation of sugar	C. R., XXII, 936.
1846	Reich	Distinguishing cane and grape sugars with bichromate, or salts of cobalt, &c.	Gewerbeverein Prov. Pruss., 1846, 8; Arch. Pharm. L., 293; Pharm. Centr., 1847, 671; J. Pharm. (3), XIII, 28; XIV, 79; J. Pr. Ch., XLIII, 71; Dingl. J., CVI, 439; Pol. Centr., 1847, 702; Pharm. Centr., 1847, 671.
1846	Schiel	Gall converts sugar into fat	A. C. P., LVIII, 96.
1846	Soleil	Description of saccharimeter (new).	Bull. Soc. d'Enc., 1846, 543; Dingl. J., CIV, 276.
1846	Soubeiran	Experiments on fruit and starch sugars.	J. Pharm. (3), IX, 327; Pharm. Centr., 1846, 475; Chem. Gaz., V 8.

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1846		Sugar as partial substitute for barley in beer.	London Times, Jan. 14, 1847; Dingl. J., CIII, 318.
1847	Becquerel	Report on Soleil's improved saccharimeter.	Bull. Soc. d'Enc., 1847, 545; Dingl. J., CVII, 343.
1847	Dubrunfaut	Distinction between malt sugar and grape sugar.	C. R., XXV, 308; Pharm. Centr., 1847, 783; Pol. Centr., 1847, 1542.
1847	do	Glucose (maltose)	A. c. p., XXI, 178; Dingl. J., CVII, 358 (see below).
1847	do	Analytical property of vinous and lactic fermentation; its use in recognizing the sugars.	A. c. p. (3), XXI, 169; C. R., XXV, 307; Dingl. J., CVII, 351; J. Pr. Ch., XLII, 418; Pharm. Centr., 1847, 889; Pharm. Centr., 1848, 10; J. B., 1848, 792.
1847	do	On glucose (maltose)	C. R., XLI, 228; J. Pr. Ch., XLII, 425; LXVIII, 422.
1847	Guibourt	Distinguishing starch from cane sugar.	J. Pharm. (3), XIII, 263; J. B. 1847–8, 983.
1847	Stöckhardt	Adulterations of sugar and honey.	Pol. Centr., 1847, 266.
1847	Strahl	Formation of sugar in the animal organization.	Archiv. Anat., 1847, 215; Pharm. Centr., 1847, 491.
1848	Balard	Report on saccharimeter prize	Bull. Soc. d'Enc., 1848, 171; Dingle J., CVIII, 375.
1848	Chevallier	Adulteration of loaf sugar with starch sugar.	J. Chim. Med. Mar., 1848; Dingl. J., CVIII, 319.
1848	Lespian	Estimation of urine sugar with the saccharimeter.	C. R., XXVI, 306; Pharm. Centr., 1848, 336.
1848	Reich	Adulteration of cane sugar with grape and starch sugar.	J. Pr. Ch., XLIII, 71. Med. Times.
1849	Aldridge	Grape sugar in egg albumen	J. Pharm. (3), XV, 366; Dingl. J., CXII, 463; A. C. P., LXXII, 319; J. B., 1849, 513.
1849	Bernard	Brain wound causes sugar in urine.	C. R., XXVIII, 393; Chem. Gaz., VII, 198; Dingl. J., CXIII, 158; Pharm. Centr., 1849, 697.
1849	Clerget	Saccharimetry by polarization	A. c. p. (3), XXVI, 175: A. C. P., LXXII, 145.
1849	Dubrunfaut	Invert sugar, honey and the sugar on raisins.	C. R., XXIX, 51; Dingl. J., CXIII, 387; Pharm. Centr., 1849, 643; Instit., 1849. 242; J. B., 1849, 464.
1849	Fehling	Action of sugar upon alkaline copper solutions.	A. C. P., LXXII, 106.
1849	Schulze	Action of glucose and sulphuric acid on organic substances.	A. C. P., LXXI, 266; J. de Pharm. (3), XVII, 145.
1849	Soubeiran	Composition of honey, and some properties of its sugar.	C. R., XXVIII, 774; J. de Pharm., XVI, 252; J. Pr. Ch., XLIX, 65; Chem. Gaz., VII, 318; Dingl. J., CXIV, 370.
1850	Fehling	Quantity of sugar in grape must.	Württ. Wocheubl, 1850, Apr; Pol. Centr., 1850, 739.
1850	do	Quantitative estimation of sugar with copper solution.	A. C. P., LXXII, 106; Dingl. J., CXVII, 276.
1850	Lassaigne	Cane sugar that has been heated will reduce copper sol.	J. Chim. Med. (3), VI, 373; Chem. Gaz., 1850, 442; Phil. Mag. (3), XXVII, 314; J. B., 1850, 615.
1850	Laurent	Dulcose	C. R., XXX, 41; 339.
1850	Maumene	Merino and stannic chloride test for sugar.	C. R., XXX, 314, 447; Instit., 1850, 92, 122; Dingl. J., CXVI, 59; J. Pharm. (3), XVII, 368; Pharm. Centr., 1850, 349.
1850	Mulder	On the Trommer-Barreswil, Schwartz, and Fehling tests.	Scheik. Verh. en Onderz., V, 385; J. B., 1850, 614.
1850	Soubeiran	Detection of starch sirup in commercial sugars optically.	J. Pharm. (3), XVIII, 328; Dingl. J., CXIX, 142; Pol. Centr., 1851, 438, 570; J. B., 1850, 613.
1850	Wilhelmy	The law that governs the action of acids on cane sugar.	Pogg., LXXXI, 413.
1851	Casaseca	Silver salts reduced by sugar.	C. R., XXXII, 686; XXXIV, 111.
1851	Clerget	Remarks on Dubrunfaut's saccharimeter (see below).	C. R., XXXII, 305; XXXIII, 32; Dingl. J., CXXX, 303.
1851	Donaldson	Reagent for sugar in blood	J. Chim. Med., 1851, 641; Dingl. J., CXXII, 399.
1851	Dubrunfaut	Saccharimetry	C. R., XXXII, 249; Pharm. Centr., 1851, 278; Dingl. J., CXXI, 299; Pol. Centr., 1851, 738.
1851	Ludersdorf	Maize for sugar making	Ann. Landwirtschaft; Zeitsch. für Landwirth, 1851; Pol. Centr., 1851, 1447.
1851	Pasteur	Combination of grape sugar and sodium chloride. Relation of crystalline form to chemical composition and polarization.	A. c. p. (3), XXXI, 92; J. Pr. Ch., LII, 413; A. C. P., LXXX, 150; J. B., 1850, 534.

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1851	Rübsamen	Adulteration of brown sugar with 58 per cent. starch; only 30 per cent. cane sugar.	Jahrb. Prak. Pharm., XXII, 197; Pol. Centr., 1852, 56; J. Pharm. (3), XX, 401.
1851	Soubeiran	Detecting starch sugar in cane sirups.	Dingl. J., CXXV, 292 (CXIX, 142); J. B., 1851, 647.
1852	Barreswil	Sugar in urine	J. Pharm. (3), XXI, 27.
1852	Baumert	Sugar in blood	J. Pr. Ch., LIV, 357; Pharm. Centr., 1852, 192; J. B., 1851, 591.
1852	L'hermite	Conversion of mannite into sugar by yeast.	C. R., XXXIV, 114; Pharm. Centr., 1852, 160.
1852	Pohl	Cold produced by dissolving grape sugar.	Wien. Acad. Ber., VI, 598; J. Pr. Ch., LVI, 218.
1853	Faisst	Quantity of sugar in fruits and berries.	Würtemberg Gew., 1853, 6, 7; Dingl. J., CXXVII, 316.
1853	Fouchard	Granular starch sugar	Bull. Soc. d'Enc., LII, 145; Poly. Centr., 1853, 1407.
1853	Petzholdt	Solubility of quartz in sugar sol	J. Pr. Chem., LX., 368.
1853	Rigaud	Action of sugar on copper sol	A. C. P., XC., 297.
1854	....	Bitter taste of starch sugar caused by excess of lime; add tartaric or acetic acid.	Monat. Nachr., 1854, 1; Poly. Centr., 1854, 252.
1854	Arnould	Dextrine, sugar, and alcohol from wood.	C. R., XXXIX, 807; Dingl. J., CXXXIV, 219.
1854	Lawes & Gilbert	Equivalency of starch and sugar in food.	Brit. Assoc., XXIV, 70; Chem. Gaz., XII, 396.
1854	Horsley	Alkaline chromate test for sugar	Chem. Gaz., 1854, 314; J. Pr. Ch., LXIII, 320.
1854	Lahens	Glucose in opium, lactucarium, and vegetables generally.	J. Pharm. (3), XXVI, 263.
1854	Maumené	Quantitative estimation of sugar with chloride of tin.	Monit. Ind., 1854, 1888; Dingl. J., CXXXIII, 376; C. R., XXXIX, 422; Pharm. Centr., 1854, 735.
1854	......do	Changes pure water causes in sugar; and on analysis of sirups.	C. R., XXXIX, 914; Dingl. J., CXXXV, 59; Pol. Centr., 1855, 624.
1854	Rigaud	Grape and milk sugar reduce unequal quantities of copper.	A. c. p., XC, 297; Pharm. Centr., 1854, 768; J. B., 1854, 746.
1854	Schunck	Action of madder ferment on sugar.	Memoir. Lit. and Phil. Soc., Manchester, XII, 109; Phil. Mag. (4), VIII, 161; J. Pr. Ch., LXIII, 222; Phar. Centr., 1854, 813; J. B., 1854, 620.
1854	Städeler	Grape sugar and sodium chloride.	Mitth. Nat. Ges., Zurich, 1854, 473; Chem. Gaz., XIII, 44, 67; Pharm. Centr., 1854, 936; J. B., 1854, 746.
1855	Baudrimont	Quantity of sugar in urine varies at different hours.	C. R., XLI, 176; J. Pr. Ch., LXVII, 188; Pharm. Centr., 1855, 704.
1855	Béchamp	Action of water on cane sugar in presence of $CaCl_2$ or $ZuCl_2$.	C. R., XL, 437; Instit., 1855, 90; Poly. Centr., 1855, 624; J. Pharm. (3), XXVII. 274; J. B., 1855, 670.
1855	Becken	Changes that sugar undergoes during nutrition.	J. Pharm. (3), XXVII, 298.
1855	Berthelot	Neutral compound of acid with saccharine bodies.	Gaz. Med., Paris, 1857, 1; N. Rep. Pharm., VI, 67; C. R., XLI, 452; Instit., 1855, 322; J. Pr. Ch. LXVII, 235; J. B., 1855, 675.
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1855	Boedeker	Fehling's solution	Henle's Zeit. Rat. Med., VI, 2; Schmidt's Jahrb. Ges. Med., LXXXVIII, 156; J. B., 1855, 819.
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1855	Leplay	Manufacture of sugar from grain by sulphuric acid.	Genie Ind., 1855, 297; Dingl. J., CXXXVIII, 424.
1855	Melsens	Method of using various vegetable substances (cellulose) to make fruit sugar.	Genie Ind., 1855. 106; Dingl. J., CXXXVIII, 426.
1855	Reynoso	Action of glucose on copper salts	C. R., XLI, 278; J. Pr. Ch., LXVI, 465; Pharm. Centr., 1855, 720; Chem. Gaz., XIII, 385.
1855	Schunck	Sugar by action of acids on Indican.	J. Pr. Ch., LXVI, 330; Phil. Mag. (4), X, 73.
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1856	......do	Products of fermentation	Instit., 1856, 267; Ch. Centr., 1856, 749.
1856	Biot	On the use of the term "Glucose".	C. R., XLII, 351; J. Pr. Ch., LXVIII, 429; Pharm. Centr., 1856, 255; Instit., 1856, 92; J. B., 1856, 638.
1856	Dubrunfaut	Birotatory power of "Krümel" sugar (glucose mamelone) and milk sugar.	C. R., XLII, 228; 739; 901; Instit., 1856, 161; J. Pr. Ch., XLII, 425; J. Pr. Ch., LXVIII, 422; LXIX, 438; Pharm. Centr., 1856, 233: J. B., 1856, 640.
1856	Gall	Improved method of neutralizing with aid of acetic acid.	Gall's Prakt. Mitth., I, 149; Pharm. Centr., 1856, 80; Pol. Centr., 1856, 62; Dingl. J., CXXXVIII, 239; Wag., 1855, 199.
1856	......do	An intentionally adulterated glucose with bad odor.	Pol. Notizbl., 1856, 367; Dingl. J., CXXXIX, 468.
1856	Graham, Stenhouse & Campbell.	Percentage of sugar in coffee	Quar. J. Ch. Soc., IX, 33; J. Pr. Ch., LXIX, 188.
1856	Siegle	Preparation of pure grape sugar from honey.	J. Pr. Ch., LXIX, 148; Ch. Centr., 1856, 960; Pol. Centr., 1856, 206; J. Pharm. (3), XXXI, 240; J. B., 1856, 638; Wag., 1856, 225.
1856	Völcker	Saint John's bread contains 41.2 per cent. grape sugar.	Dingl. J., CXLVI, 390.
1856	Von Kobell	Crystalline form of the compound of grape sugar and sodium chloride.	J. Pr. Ch., XXVIII, 489; J. Pr. Ch., LXIX, 218.
1856	Wicke and Listing	Quantitative determination of sugar in diabetic urine.	J. Pr. Ch., LXVII, 134; A. C. P. XCVI, 87; 93.
1858		Extent of the starch sugar industry in Germany.	Pol. Centralblatt, 1856, No. 14.
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1857	Berthelot	Alcoholic fermentation	C. R., XLIV, 702; LX, 29; J. Pr. Ch., LXXI, 321; A. c. p. (3) L, 322.
1857	......do	A peculiar sugar from mannite and glycerine.	C. R., XLIV, 1002; J. Pr. Ch., LXXI, 507; A. c. p. (3) L, 369.
1857	......do	Compounds of saccharine substances with tartaric acid.	C. R., XLV, 268; Inst., 1857, 283; J. Pr. Ch., LXXIII, 157; A. c. p., (3) LIV, 74; J. Pharm. (3), XXXIII, 95; Ch. Gaz., 1857, 441; J. B., 1857, 506.
1857	Bernard, Sanson and Figuier.	Formation of sugar in the liver	C. R., XLIV, 578; 1159; 1213; 1321; 1323; 1525.
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1857	Pelouze	Influence of free alkali on fermentation of starch and urine sugars.	Cosmos, X, 390; Dingl. J., CXLIV, 319.
1857	Schiff	Amount of copper reduced by grape and milk sugars.	A. C. P., CIV, 330; J. Pr. Ch., LXXIII, 314.
1858	Balling	Grape sugar	Dingl. J., CXLVII, 78; Pol. Centr., 1858, 349.
1858	Béchamp	Conversion of cane sugar into fruit sugar by water and different solutions.	C. R., XLVI, 44; Pol. Centr., 1858, 595; Dingl. J., CXLIX, 207; A. c. p. (3), LIV, 28; Pol. Centr., 1858, 595.
1858	Berthelot	Fermentation of cane sugar and glucose.	N. Rep. Pharm., VII, 187.
1858	......do	Conversion of certain constituents of shell-fish into sugar.	C. R., XLVII, 227; Ch. Centr., 1858, 675.
1858	......do	Melezitose in manna	C. R., XLVII, 224; J. Pr. Ch., LXXVI, 188; A. c. p. (3), LV, 269.
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1858	Fehling	Quantitative estimation of sugar	A. C. P., CVI, 75; Ch. Centr., 1858, 527; Dingl. J., CXLVIII, 454; Pol. Centr., 1858, 1014; J. Pr. Ch., LXXIV, 371; Ch. Gaz., 1858, 297; J. B., 1858, 634.
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1858	Marx	Percentage of sugar in grape and fruit juices in 1857.	Würt. Land & Forst Wirth. Dingl. J., CL, 143; Ch. Centr., 1858, 918; J. B., 1858, 658; Wag., 1858, 330.
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1859	......do	Influence of argols and tartaric acid on fermentation of grape juice and pure sugar solution.	Dingl. J., CLIV, 223.
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1861	Payen	Dextrine and sugar from starch by action of acid or yeast.	C. R., LIII, 1217; 678 and 733; Dingl. J., CLXIV, 144; Bayer, Kunst & Gewerb., 1862, 437, 678, 733; Rep. Chim. Appl., IV, 36; Landwirth. Centr., 1862, I, 227; Pol. Centr., 1862, 680; W. G. B., 1862, 403; J. B., 1861, 717.
1861	Pohl	Preparation caramel and assamar.	Wien. Akad. Ber., XLI, 623; J. Pr. Ch., LXXXII, 48.
1861	Schmidt	Detection of grape in cane sugar with lead acetate and ammonia.	A. C. P., CXIV, 102; CXIX, 102; Dingl. J., CLXI, 399; Z. Anal. Chem., I, 96; Chem. News V., 98, 213; Pol. Notizb., 1861, 304; Wag. J. B., 1861, 429.
1861	Schmidt	Grape sugar from salicine and amygdaline.	A. C. P., XXIX, 92.
1861	Zwenger and Kind	Glucose from solanine	A. C. P., CXVIII, 149.
1861		Sugar in urine of the fox	Wien. Akad. Ber., LII, 523; Ch. News, IV, 247.
1862	Anthon	Sodium chloride and grape sugar soluble in 0.66 water.	Dingl. J., CLXVI, 69; J. B., 1862, 472.
1862	Berthelot	Compound of glucose with stearic acid.	A. c. p. (3), LX, 93; J. B. Zucker Fab., I, 204.
1862	Boedeker	Specific gravity of different sugars.	J. B. Zucker Fab., I, 203.
1862	Iodin	Isomeric transformation of cane sugar under the influence of a specific ferment.	C. R., LV, 720; LVIII, 434; Bull. Soc. Chim., 1863, 93; Chem. Centr., 1863. 72; J. B., 1862, 472.
1862	Löwenthal and Leussen.	Influence of time, temperature, nature, and strength of acid used.	J. Pr. Ch., LXXXV, 321.
1862	Musculus	Conversion of starch into dextrine and sugar.	C. R., LIV, 194; Dingl. J., CLXIV, 150; Z. C. P., 1862, 169; Pol. Centr., 1862, 680; Rep. Chem. Pure, IV, 148; Schweiz Pol. Zeit., 1862, 167; Bayer. Kunst & Gew., 1862, 438; J. B. 1861, 719; Wag. J. B. 1862, 404.

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1862	Rosenstiehl	Attempted synthesis of glucose from $C_{12}H_6Cl_6$.	C. R., LIV, 178; J. Pr. Ch., LXXXVIII, 58; Rep. Chim. Pure., IV, 149; Z. C. P., 1862, 279; Chem. Centr., 1862, 810; J. B., 1862, 480.
1862	Schunck	Sugar formed in normal urine by boiling with acid.	Phil. Mag. (4), XXIII, 179; J. B., 1862, 543.
1863	Anthon	A method for preparing starch sugar of pure flavor, intensely sweet hard, and crystalline.	Dingl. J., CLXVIII, 456; Pol. Notizb., XVIII, 154; J. Pharm. (3), XLIV, 173; Ch. News, VIII, 42; Ch. Centr., 1864, 144; Wurt. Gewerbebl., 1863, 299; Pol. Centr., 1863, 1181; New Erfind., 1863, 108; Sc. Amer., XI, 343; J. B., 1863, 767; Wag. J. B., 1863, 471.
1863	Boettger	Action of chloride of lime upon sugars and starch.	Dingl. J., CLXIX, 316.
1863	Brunner	Estimation of sugar with Fehling's solution.	Pol. Centr., 1863, 561; Rep. Chim., Appl., 1863, 364; Wag. J. B., 1863, 364.
1863	Gorup-Besanez	Action of ozone on glucose	A. C. P., CXXV, 211; Ch. Centr., 1863, 473; Bull. Soc. Chim., V, 420; J. B., 1863, 141.
1863	Grouven	Formation of sugar in the potato mash.	Dingl. J., CLXIX, 238.
1863	Hornemann	Formation of tartaric and racemic acid by action of nitric acid on carbohydrates.	J. Pr. Ch., LXXXIX, 283; C. C., 1864, 150; J. B., 1863, 380.
1863	Monier	Transformation of sugar into glucose by heat.	C. R., LVI, 663; J. Pharm. (3), XLV, 161; Dingl. J., CLXIX, 147; C. C., 1863, 589; Wag. J. B., 1863, 472.
1863	Pohl	Test for starch sugar in wine	Behelfe zum Gallis., d. Weine, 65, Wag. J. B., 1863, 472.
1863	Reichardt	Action of grape sugar on copper solutions.	A. C. P., CXXVII, 297; J. Pharm. (3), XLIV, 453; Archiv. Pharm. (2), CXVII, 29; C. C., 1864, 45; Bull. Soc. Chim. (2), VI, 197.
1863	Reischauer	Estimation of sugar and dextrine in beer.	N. Rep. für Pharm., XI, 50; Z. Anal. Chem., II, 233; C. C., 1864, 367; J. B., 1863, 711.
1863	Roders	Honey made by bees when fed on glucose.	Archiv. Pharm. (2), CXVI, 29; Dingl. J., CLXIX, 158; J. B. Zuck. Fab., IV, 189, III, 225; Vierteljahr, Pr. Pharm., XIII, 214; Z. C. P., 1863, 259; C. C., 1863, 1008; J. B., 1863, 1008.
1863	Scheibler	Action of light on solutions of invert sugar.	Dingl., CLXIX, 379; J. Pharm. (3), XLIV, 452; Bull. Soc. Chim., VI, 281; Pol. Centr., 1863, 1518; Pol. Notizb., 1863, 294; J. B. Zuck. Fab., 1863, 194; J. B., 1863, 574; Wag. J. B., 1863, 473.
1863	Schönbein	Catalytic activity of organic materials like gluten, emulsine, myrosine, yeast, and saliva.	J. Pr. Ch., LXXXIX, 323.
1863	Vogel	Use of dialyser in estimating glucose in beer.	C. C., 1862, 1244; Ch. News, VII, 179.
1864	Brunner and Vogel	Chloride of silver reduced by starch sugar.	Dingl. J., CLXXI, 363; J. Pr. Ch., LXXXVI, 326; XCI, 254; C. C., 1864, 880, 926; J. B., 1864, 285.
1864	Iodin	Influence of optically inactive substances on the rotatory power of sugar.	Bull. Soc. Chim. (2), I, 432; C. R., LVIII, 613; Instit., 1864, 114; Dingl. J., CLXXIII, 143; C. C., 1864, 477; Pol. Centr., 1865, 77; J. B., 1864, 573.
1864	Leuchs	Thin starch paste converted into sugar by raw potato parings at 45° to 50° C.	J. Pr. Ch., XCII, 59; Dingl. J., CLXXIII, 157; C. C., 1864, 1088; Bull. Soc. Chim. (2), II, 393; J. B., 1864, 571.
1864	Leuchs	Relative value of different sugars as food for yeast cells.	J. Pr. Ch., XCIII, 409, 399; C. C., 1865, 389; Bull. Soc. Chim. (2), IV, 155; J. B., 1864, 579.
1864	Manbré	Manufacture of starch sugar with acid, at 135° to 160° Centigrade.	Mech. Mag., Nov. 1864, 337, 475; Dingl. J., CLXXV, 309; C. C., 1865, 720; J. Pharm. (4), II, 413; Pol. Centr., 1865, 544; Sc. Amer., XII, 21; J. B., 1865, 825; Wag., J. B., 1865, 500.
1864	Millon	Changes in sugar by fermentation; NH_3 formed.	C. R., LVII, 325; LIX, 144; J. pr Ch., XCIII, 9; J. B., 1864, 579.
1864	Duclaux	do	C. R., LVIII, 1114.

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1864	Spirgatis	Glucose from turpeth root	J. Pharm. (4), I, 236; J. pr. Ch. XCII, 102; Z. C. P., 1864, 442; C. C., 1864. 763; Viertelj. pr. Pharm., XIV, 386; Bull. soc. Chim. (2), II 382; Inst., 1864, 403; J. B., 1864, 591.
1864	Stenhouse	Compound of dextro-glucose and sodium bromide.	J. Ch. Soc. (2), I, 297; J. pr. Ch., XCII, 350; A. C. P., CXXIX, 286; C. C., 1864, 64; Bull. Soc. Chim. (2), VI, 60; J. B., 1863, 574.
1865	Blondeau	Sugar a product of slow decomposition of gun-cotton.	C. R., LX, 128, LXI, 378; J. pr. Ch., XCIV, 64, 318; Instit., 1865, 299; C. C., 1865, 997; Dingl. J., CLXXVIII, 147; J. B., 1865, 575.
1865	Boussingault	Formation of glucose by leaves	C. R., LX, 872; LXI, 664; Instit. 1865, 322, 329, 354; Ch. News, XII, 293; Bull. Soc. Chim. (2), III, 444; V, 396; Z. C., 1865, 535 731; C. C., 1865, 628, 983, 1153; J. B., 1865, 615.
1865	Braun	Picric acid test for glucose	Z. anal. Chem., IV, 187; Z. C., 1865, 744; Dingl. J., CLXXX, 327; C. C., 1866, 218; J. pr. ch., XCVI, 414; J. Pharm. (4), III, 474; Pol. Notizbl., 1865, 27; J. B., 1865, 526; Wag. J. B., 1866, 399.
1865	Carius	Synthesis of Phenose $C_6H_{12}O_6$, an isomere of glucose.	A. C. P., CXXXIV, 71; CXXXVI, 323; Z. C., 1866, 67; A. c. p. (4), VIII, 193; C. C., 1866, 84; Bull. Soc. Chim. (2), VI, 61; Phil. Mag. (4), XXXI, 453; Ch. News, XIII, 161; J. B., 1865, 533.
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1865	Nickles	Bichloride of carbon for distinguishing grape from cane sugar.	C. R., LXI, 1053; Bull. Soc. Chim. (2), VI, 90; Deut. Ind. Zeit., 1866, 45; J. pr. Ch., XCVII, 439; Dingl. J., CLXXIX, 315; Instit., 1865, 396; Ch. News, XII, 299; Z. Anal., Chem., V. 412; J. Pharm. (4), III, 119; Z. C., 1866, 96; C. C., 1866, 527; J. B., 1865, 601; Wag. J. B., 1865, 501; 1866, 400.
1865	Payen	Action of diastase on starch	A. c. p. (4), IV, 286; Bull. Soc. Chim. (2) III, 470; Dingl. J., CLXXVIII, 69; J. Pharm. (4), I, 363; C. C., 1865, 845; Vierteljj. pr. Pharm., XV, 221; J. B., 1865, 597.
1865	Schützenberger	Action of anhydrous-acetic acid upon cellulose, starch, and sugar.	C. R., LXI, 485; J. B., 1865, 594; A. c. p. (4), XXI, 249.
1865	......do	Some further experiments on the same.	Bull. Soc. Chim. (2), V, 290; Z. C., 1866, 16; C. C., 1865, 1036; J. pr. ch., XCVII. 250; J. Pharm. (4), II, 376.
1866	Anders	Technical estimation by polariscope and sources of error.	Zeit. ver. d. Ing., X, 321; Dingl. J., CXXXII, 331; J. B., 1866, 882.
1866	Assmuss	Caramel from glucose	Fab. Zuckercouleur, Berlin, 1866; Deut. Ind. Zeit., 1866, 222; Bull. Soc. d'Enc., LXVI, 534; Dingl. J., CLXXXI, 334; Pol. centr., 1866, 893; Pol. Notizbl., 1866, 210; Wag. J. B., 1866, 401.
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1866	Lawes	Estimation of sugar in barley	Ch. News, XIII, 161, 191.
1866	Payen	Dextrine and glucose from starch	A. c. p. (4), VII, 393; Z. C., 1866, 334.
1866	Stahlschmidt	Estimation of sugar by ferrocyanides.	Z. Anal. Chem. VII, 494.
1867	Boussingault	Non-fermentable reducing substance in black cherries.	A. c. p. (4), VIII, 231; J. B., 1867, 741.
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1867	Phillipp	Estimation of starch	Z. C. (N. S.), III, 400; Z. anal. Chem., VI, 471; Bull. Soc. Chim. (2), VIII, 363.
1867	Sestini	Sugar in dried fruits	Bull. Soc. Chim. (2), VII, 236; Wag. J. B., 1867, 443.
1867	Sherlock	Caramel from starch sugar	Ch. News, XV, 282; Dingl. J., CLXXXV, 236; Pol. centr., 1867, 1215; Wag. J. B., 1867, 441.
1867	Thompson	Caramel from glucose	Chem. News, XV, 242.
1868	Boettger	Starch sugar for gilding on glass	Pol. Notizbl., 1868, 129; J. pr. Ch., CIII, 414; Dingl. J., CLXXXVIII, 288; Pol. Centr., 1868, 984; C. C., 1868, 1053; Bull. Soc. Chim. (2), X, 164; Schweiz pol. Zeit., 1868, 114; Fürther Gewerb, 1868, 64; Hess. Gewerb., 1868, 223; Deut. Ind. Zeit., 1868, 194; J. B., 1868, 944; Wag. J. B., 1868, 194.
1868	Classen	Cane sugar inverted by water and neutral solutions of salts.	J. pr. Ch., CIII, 449; J. B., 1868, 758; A. C. P., CXLVII, 114.
1868	Claus	Conversion of grape sugar into tartronic acid by cupric oxide.	A. c. p. (4), XVI, 466; J. pr. Ch., CVI, 125; CXII, 63; J. Pharm. (4), X, 234; Z. C., 1869, 152; C. C., 1868, 556; Ch. News, XIX, 250; Bull. Soc. Chim. (2), XI, 157; J. B., 1868, 759.
1868	Commaille	Reduction of copper oxide to metal by invert sugar.	J. Pharm. (4), VIII, 18; Chem. News, XVIII, 181; Z. C., 1868, 719; J. B., 1868, 269.
1868	Dobell	Action of pancreas on fats and starch.	Proc. Roy. Soc., XVI, 209; J. pr. Ch., CIV, 443; J. B., 1868, 830.
1868	Dubrunfaut	Conversion of starch into sugar by malt, and on the preparation of a nitrogenous substance from malt, more active than diastase. Maltine.	C. R., LXVI, 274; Les Mondes, XVI, 317; C. C., 1868, 1062; Dingl. J., CLXXXVII, 491; Pol. centr., 1868, 759; Z. C., 1868, 351; Bull. Soc. Chim. (2), X, 54; J. B., 1868, 799.
1868	Gräger	Conversion of cane into grape sugar by parasites of vine.	N. Jahrb. Pharm., XXIX, 294; Pol. centr., 1869; J. B. 1868, 759.
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1868	Scheibler	Effects of the glass cover in the optical estimation of sugar.	Berl. Ber, I, 268; Z. Anal. C., VIII, 211; N. Jahrb. Pharm., XXIX, 270; Z. Anal. C., VII, 491.
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1869	Dubrunfaut	Inversion of cane sugar is attended with contraction.	C. R., LXIX, 1199.
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1871	Campani	Testing urine for glucose with acetate of lead and copper.	Arch. Pharm., CXCVIII, 51; Berl. Ber., IV, 415; Z. Anal. C., XI, 321; Pol. Notizbl., XXVII, 47; Les Mondes, XXXII, 74; Ch. News, XXVIII, 170; J. B., 1871, 968.
1871	Claus	Decomposition of grape sugar by copper oxide.	J. Pr. Ch., CXII, 63; J. B., 1871, 795.
1871	Gill	Effect of acetate of lead on rotatory power of glucose solutions.	Ch. News, XXIII, 139; Berl. Ber., IV, 283; J. Ch. Soc. (3), IX, 85, 91; Z. Anal., C. X, 490; C. C., 1871, 237; Sugar Cane, III, 303; Les Mondes, XXXIII, 778; J. B., 1871, 965; Wag. J. B., 1871, 599.
1871	Gräger	Fruit sugar and sirups	Dingl. J., CCI, 268.
1871	Griessmayer	Fruit sirups	Bierbrauer, 1871, 96; Pol. Centr., 1871, 1122; Pol. Notizbl., 1871, 316; Wag. J. B., 1871, 603.
1871	Hardy	Glucose in beet sugar	J. Pharm. (4) XIII, 311.
1871	Hoppe-Seyler	Lactic acid from glucose by alkalies without fermentation.	Berl. Ber., IV, 346; Z. C., 1871, 507; C. C., 1871, 389; Bull. Soc. Chim. (2), XV, 231; A. c. p. (4), XXV, 193; J. B., 1871, 561.
1871	do	Glucose from saccharose by beer yeast. The ferment described.	Berl. Ber., IV, 810.

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1871	Jean	Estimating glucose with copper and silver.	C. R., LXXIII, 1397; C. C., 1872, 9; Ch. News., XXV, 33; J. Pharm. (4), XV, 206; Z. anal. C. XII, 111; Dingl. J., CCIII, 158; Monit. Scient., 1872, 75, 278; Wag. J. B., 1872, 515.
1871	Joy	Glucose	Ch. News, XXIII, 74; Sugar Cane, III, 182.
1871	Maly	Trommer's test in urine	Wien. Akad. Ber., LXIII, 2te Ab. 477; Z. anal. C. X, 382; J. Pharm. (4), XVI, 147; C. C. 1871, 601; J. B., 1871, 968.
1871	Monier	Percentage of glucose and dextrine in the beer sold in Paris; 7 to 11.6 per 1.000.	Bull. soc. d'Encour, LXX, 525.
1871	Phipson	Estimating glucose in cane and beet sugars, volumetrically.	Sugar cane, III, 423.
1871	Pillitz	Estimation of sugar	Z. anal. C. X, 456.
1871	Raoult	Conversion of cane into grape sugar by light.	C. R., LXXIII, 1049; J. Pharm. (4), XIV, 415; A. c. p. (4), XXIII, 291; A. C. P., CLXII, 272; Dingl. J., CCIII, 79; C. C. 1871, 757; Pol. Centr., 1872, 79; Z. C., 1871, 536 Ch. News, XXIV, 252; J. B., 1871 795.
1871	Sachsse	Action of glucose on aniline	Berl. Ber., IV, 836; J. B., 1871, 797.
1871	Schiff	Action of glucose on aniline	Berl. Ber., IV, 908; A. C. P., CXL, 123; CLIV, 30; J. B., 1871, 798.
1871	Seegen	No reliable test for traces of sugar in urine.	Wien. Akad. Ber., LXIV, 2te Ab. 6; Z. Anal. C. X. 501; J. Pharm. (4), XVI, 364; Pharm. J., & Trans. (3), II, 202; J. B., 1871, 968.
1871	Vivien	Analysis of sirups	Ch. News, XXIII, 281; Am. Chem., I, 258; C. C., 1871, I, 455.
1872	Barfoed	No sugar formed when dextrine ferments.	J. pr. Ch., CXIV (N. S., VI), 334; Arch. Pharm.; J. Pharm. (4), XVIII, 248; J. B., 1872, 771.
1872	Borodulin	Cane sugar not converted into inactive sugar by silver nitrate.	Berl. Ber., V, 477; J. B., 1872, 783.
1872	Bouchardat	Isopropylic, ethylic, and hexylic alcohol formed by hydrogenating the glucoses.	A. c. p. (4), XXVII, 87; Berl. Ber., V, 324.
1872	Brunner	Estimating sugar with Fehling's solution.	Z. anal. C., XI, 32; C. C., 1872, 392; J. B.. 1872, 931, Wag. J. B., 1872, 515.
1872	Chancel	Sugar solutions contract at the moment of inversion.	C. R., LXXIV, 376; J. B., 1872, 1035.
1872	Dumas	On ferments belonging to the diastase group.	C. R., LXXV, 295; Bull. soc. d'Encour, LXXII, 49; Monit. Scientif., 1872, 744; Ch. News, 1872, 82; C. C., 1872, 567; Wag. J. B., 1872, 542.
1872	Feltz	Uncertainty of Trommer's test for estimating glucose in saccharose.	C. R., LXXV, 962; LXXVI, 1140; Berl. Ber., V, 881; Dingl. J., CCVI, 384; J. B., 1872, 783; 1873, 966.
1872	......do	Action of crystallized sugar on tartrate of copper.	C. R., LXXV, 960; LXXVI, 1140; Dingl. J., CCVI, 384; J. Pharm. (4) XVII, 42; XVIII, 98.
1872	Feltz	Alkaline treatment of sirups increases the quantity of glucose.	Sugar Cane, IV, 225.
1872	Krötke	Manufacture of starch sugar	Dingl. J., CCIV, 243; Tech., Apr., 1872; Am. Chem., III, 78; J. B., 1872, 1022.
1872	......do	Preparation of sugar color from starch sugar.	Dingl. J., CCIV, 241; Pol. Notizbl., XXVII, 179; Pol. Centr., 1872, 881.
1872	Manassein	Roberts' test for sugar in urine	Centrl. Med., Wissen, 1872, 551; Z. anal. C., XII, 236.
1872	Musculus	Conversion of glucose into a substance resembling dextrine.	Bull. Soc. Chim. (2), XVIII, 66; Berl. Ber., V, 648; J. B.; 1872, 773; Wag., J. B., 1872, 516.
1872	Patterson	Estimation of grape sugar with Fehling's solution.	Ch. News, XXV, 149; Dingl. J., CCIV, 402; Am. Chem., III, 134; Sugar Cane, IV, 240; J. B., 1872, 929.
1872	Possoz	Estimating sugar with copper	C. R., LXXV, 1836; J. B., 1872, 931.
1872	Scheibler	Crystals of glucose and sodium chloride to standardize with.	Berl. Ber., V, 928; Dingl. J., CCVI, 386.
1872	Schulze and Märcker.	Transformation of starch by diastase.	Naturf., 1872, No. 27; Dingl. J., CCVI, 245; J. B., 1872, 771.

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1872	Seegen	Detecting traces of sugar in the urine.	Arch. physiol., V. 375; Br. Med. J. Ch. News, XXV, 272; Z. anal. C., XI, 355; J. B., 1872, 943.
1872	Softmann	Estimating water and fruit sugar in cane sugar.	Z. Zuckerfabr., XII, 214.
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1872	Weber	Starch sugar and sirup	Soc. for prom. trade in Prussia; Sc. Amer., XXVIII, 181.
1872	Weil	Volumetric estimation of sugar	A. c. p. (4), XXVII, 109; Dingl. J., CCVII, 409; Z. anal. C., XI, 284; J. B., 1872, 931.
1872		History of grape sugar manufacture.	J. App. Sci.; Monit. Scientif. (3), III, 426; J. B., 1873, 1069.
1873	Barfoed	Testing for grape sugar in presence of dextrine with copper acetate.	Z. anal. C., XII, 27; Monit. Scientif., XVI, 751; J. B., 1873, 969.
1873	Borodulin	Action of potassium permanganate on invert sugar.	Berl. Ber., VI, 1207; J. B., 1873, 832.
1873	Classen	Action of water and neutral salt solutions on cane sugar.	Sugar Cane, V, 557; Les Mondes, XXXIII; Ch. News, XXIX, 93.
1873	Deherain	Absorption of nitrogen by alkaline solution of glucose and humus.	C. R., LXXVI, 1390; Berl. Ber., VI, 679; Bull. Soc. Chim. (2), XIX, 538; J. B., 1873, 1044.
1873	Jacobsen	No glucose in human bile	Berl. Ber., VI, 1027; J. B., 1873, 877.
1873	Jean	Use of ammonio-chloride of silver for estimating grape sugar.	Z. anal. C., XII, 111; J. B., 1873, 966.
1873	Jouglet	Artificial beet sugar	Assemblée Nationale; Sugar Cane, V, 505; Les Mondes, XXXI, 596, 676; Ch. News, XXVIII, 110.
1873	Krause	Fehling's test, titrating excess of copper with cyanide.	N. Rep. Pharm., XXII, 89; C. C., 1873, 185; Z. Anal. C., XII, 323; J. B., 1873, 966.
1873	Loiseau	Influence of the quantity of soda in Fehling's solution.	C. R., LXXVI, 1602; Berl. Ber., VI, 970; J. B., 1873, 965.
1873	do	Barreswil's method	C. R., LXXVI, 1602; LXXIX, 1263; J. Pharm. (4), XVIII, 169.
1873	Margueritte	Preparation of grape sugar	Bull. Soc. Chim. (2), XIX, 89; Berl. Ber., 1873, 89; Wag. J. B., 1873, 577.
1873	Mertens	Estimating glucose with mercury cyanide.	Z. Anal. C., XIII, 76; Berl. Ber., VI, 440; C. C., 1873, 537; J. B., 1873, 965; Wag. J. B., 1873, 578.
1873	Mohr	Estimating grape sugar with permanganates.	Z. anal. C., XII, 296; Z. für Zuckerind; Bull. Soc. Chim. (2), XXI, 499; Am. Chem., V, 150; J. B., 1873, 966; Wag. J. B., 1874, 694.
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1873	Possoz	Action of glucose on copper solutions treated with CO_2 or $KHCO_3$.	Berl. Ber., VI, 34.
1873	do	Use of copper in estimating sugar.	Dingl. J., CCVII, 152.
1873	Prazmowski	Modification of optical saccharimetry.	C. R., LXXVI, 1212; J. B., 1873, 175.
1873	Riffard	Estimating sugar with iron	C. R., LXXVII, 1103; J. B., 1873, 964.
1873	Salkowski	Compounds of grape sugar with copper.	Archiv. Physiol., VI, 220; Z. anal. C., XII, 98; J. B., 1873, 967.
1873	Smith, H. A	Conversion of starch into sugar in the human body.	Sugar Cane, V, 408, 445.
1873		Production of glucose in animals	Eng. Mech.; Sugar Cane, V, 119.
1873	Statistics	Number of starch sugar factories in Germany.	J. B. Zuckerfab., Vols. XIV to XVIII; Wag. J. B., 1865, 805.
1874	Bouchardat	Butyric fermentation of glucose	C. R., LXXVIII, 1145; Ch. News, XXIX, 273; J. B., 1874, 950.
1874	Braun	Picric acid test for grape sugar in cane sugar.	Ind. Blätter, 1874, No. 39; Pol. Notizbl., XXIX, 365.
1874	Dubrunfaut	Maltose	A. c. p. (3), XXI, 178.
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1874	Hollefreund	Sugar from potatoes, maize, and grain.	Dingl. J., CCXI, 327; J. B., 1873, 1179.
1874	Krause	Estimating grape sugar in beet root.	Schweiz. Wochensch Pharm., 1874, 17; Bull. Soc. Chim., XXI, 429; Ch. News, XXX, 81; Z. Anal. C., XIII, 244; J. B., 1874, 1027.
1874	Laborde	Cane sugar and glucose absorb dry ammonia and become liquid.	Monit. Scientif., XVI, 134; C. R., LXXVIII, 82; J. B., 1874, 883.
1874	Lagrange	A Fehling's solution made with dry neutral tartrate of copper, &c.	C. R., LXXIX, 1005; Dingl. J., CCXV, 361; Monit. Scientif., XVII, 538; Am. Chem., V, 428; VI, 467.
1874	Laurent	A new saccharimeter with monochromatic light.	C. R., LXXVIII, 349; Bull. Soc. Chim. (2), XXI, 243; J. B., 1874, 166.
1874	Macagno	Estimating glucose with mercuric chloride.	C. C., 1874, 314; Gazz. Chim. Ital., 1874, 267; Berl. Ber., VII, 359; J. B., 1874, 1027.
1874	Maly	Grape sugar converted into sarcolactic acid by the mucous membrane of the stomach.	A. C. P., CLXXIII, 227; Berl. Ber., VII, 1567; J. B., 1874, 926.
1874	Milne	Estimating fruit sugar in raw sugars.	Ch. News, XXX, 104; J. B., 1874, 1027.
1874	Musculus	Soluble starch	Bull. Soc. Chim. (2) XXII. 26; A. c. p. (5), II, 385; J B., 1874, 881.
1874	Péligot	Saccharine	C. R., LXXX, 920; XC, 1141.
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1874	Riffard	Estimating sugar with iron	Monit. Scientif., XVI, 83.
1874	Schiff	Estimating glucose with $HgCl_2$	Berl. Ber., VII, 359, foot note.
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1874	......do	Reduction of telluric acid by grape sugar.	Dingl. J., CCXI, 324.
1874	O'Sullivan and Schulze	Maltose	Monit. Scientif. (3), IV, 210; Dingl. J.. CCXIV, 339; Berl. Ber., VII, 1047; J. B., 1874, 884.
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1874		Adulterated sirups	Sugar Cane, VI, 58.
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1875	Kastner	Quantitative estimation of tellurium with grape and inverted sugar.	Z. anal. C., XIV, 142; J. B., 1875, 921.
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1876	Müntz	Reducing sugar in cane sugar	C. R., LXXXII, 210, 517; Org. C. V. Rübenz V, 1134; Dingl. J., CCXX, 463; J. Pharm. (4), XXIII, 170; Les Mondes, XXXIX, 451; Monit. Scientif., 1876, 738; Bull. Soc. Chim. (2), XXVI, 91; Berl. Ber., IX, 350; J. B., 1876, 842; Wag. J. B., 1876, 749.
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1876	Reyard	Glucose by electrolysis of glycerine.	C. R., LXXXII, 562; Bull. Soc. Chim. (2), XXVI, 285; J. R. Ch., IV, 157; J. B., 1876, 482.
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876		Manufacture of glucose	Sc. Amer., XXXV, 23.
876	Valentine	Preparation of dextrine maltose	Analyst, 1876, 28; Org. C. V. Rübenz, 1877, 709; Ind. Blätter, 1877, 389; Dingl. J., CCXXV, 179; Bay. Bierbrauer, 1877, 281; Wag. J. B., 1876, 779; 1877, 639.
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877	Corenwinder	Glucose in leaves of sugar beets; no cane sugar.	Berl. Ber., X, 93.
877	Eissfeld and Follenius	Estimation of glucose	Zeit. Ver. Rübenz., 762; Zeit. Ch. Grossgew, II, 437; Ch.-Tech. Reper., 1877, 599.
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1880..	Emmerling	Acetol from grape sugar	C. C., 1880, 807; J. B., 1880, 1017.
1880..	Gayon	Inactive glucose	Bull. Soc. Chim. (2), XXXIII, 253; J. B., 1880, 1022.
1880..	Girard	Preparation of pure levulose	Bull. Soc. Chim. (2), XXXIII, 146, 154: C. C., 1880, 279; J. B., 1880, 1018; J. B., Zuck Fab., XX, 166.
1880..	Gratama	Gravimetric estimation glucose	Ch. Zeit., III. 138.
1880..	Grotte and Tollens	Levulinic acid from dextrose	A. C. P., CCVI, 226.
1880..	Kiliani	Glycolic acid from levulose and dextrose.	A. C. P., CCV, 191; J. B., 1880, 768.
1880..	do	Oxidation of dextrose with dilute nitric acid.	A. C. P., CCV, 172.
1880..	do	Inulin, &c	Inaug. Disert.; A. C. P., CCV, 145; Berl. Ber., XIII, 2427; J. B., 1880, 768.
1880..	Külz	Grape sugar in the dead liver	Pflüg. Arch., XXIV, 52; Berl. Ber. XIV, 367; J. B., 1881, 1038.
1880..	do	Maltose	Pflüg. Arch., XXIV, 81.
1880..	Landolt	Rotatory power of sugars	Berl. Ber., XIII, 2329; J. B., 1880, 215.
1880..	Lindo	Brucine test for glucose	Ch. News, XXXVIII, 145; Z. anal. C., XIX, 357.
1880..	Lippmann	Inverting sugar with carbonic acid.	Oestr. Zeitsch XVIII, 222; Dingl., J., CCXXXVII, 148; Berl. Ber., 1880, 1823; J. B. Zuck. Fab., XX, 162; J. B., 1880, 1021.
1880..	Märcker	Sugar and maltose from starch	Ch. Zeit., 1880, 192; J. B., 1880, 1353.
1880..	Montard, Martin and Richet.	Intervenous injection of sugar and gum.	C. R., XC, 98; J. B., 1880, 1122.
1880..	Musculus, Von Mering and Bimmermann	Transformations of starch and glycogen by means of diastase, saliva, &c.	Centrl. Agric. Ch., 1880; Ch. News, XLII, 95.
1880..	Nessler	Analysis of potato sugar for wine.	Landw. Vers., XXVI, 207; Wag., J. B., 1880, 631.
1880..	Pavy	Estimating grape sugar with ammoniacal Fehling's solution.	Ch. News, XXXIX, 77; Berl. Ber., XIII, 1884; Z. anal C., XIX, 98.
1880..	Péligot	Lime compounds of levulose	C. R., XC, 153; J. B., 1880, 1018.
1880..	do	Saccharine from glucose	C. R., XC, 1141; J. B., 1880, 1025; Wag., J. B., 1880, 621.

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1880..	Radziszewski	Phosphorescence of grape sugar	A. C. P., CCIII, 309, 329; J. B., 1880, 192.
1880..	Redfield	Glucose	Sc. Amer. sup., X, 4126.
1880..	Riche	Glucose from maize	J. Pharm. (5) 1, 137.
1880..	Scheibler	Converting starch sugar into saccharine.	Berl. Ber., XIII, 2213.
1880..	Schlossing	Action of glucose towards nitrogen.	A. c. p. (5), XXIV, 284; Berl. Ber. XIV, 2579.
1880..	Schmitz	The non-fermentable portion of grape sugar poisonous.	J. Pharm. (5), II, 43; Ch. News, XLII, 318; Ch. Zeit., 1880, 804; J. B., 1880, 1122.
1880..	Schreiter	Salicylate of soda in copper solutions.	Monit. scientif. (3), X, 1034; Pharm. Zeit.; J. Pharm. (5), II, 312; J. B., 1880, 1117.
1880..	Salkowsky	Silver mirror with cane sugar	Zeit. physiol. Ch., IV, 133; J. B. Zuck. Fab., XX, 162; J. B., 1880, 1020.
1880..	Soxhlet	Action of glucose towards alkaline, copper and mercury solutions.	J. pr. Ch., CXXIX (XXI), 227, 242; Berl. Ber., XIII, 827; J. B., 1880, 1011.
1880..	Urech	Inversion of cane sugar	Berl. Ber., XIII, 1696; J. B., 1880, 1021.
1880..	Valente	Synthesis of glucose from glycerine by Zuino an error.	Berl. Ber., XIII, 2431; Gazz. chim. Ital., X, 540; J. B., 1880, 1017.
1880..	Wiley	Estimation of starch sugar in cane sugar.	J. Am. Ch. Soc., 1880, 387; Berl. Ber., XIV, 1584.
1880..	Wolff	Glucose	Sc. Am. Sup., X, 4127, 4139.
1880..		Action diastase checked by excess of maltose and dextrose.	Brewers' Guardian, Les Mondes, LIII, 59.
1880..		Use of maize in making starch, sugar, spirits, and beer.	Dingl., J., CCXXXVIII, 488.
1880..		Glucose for confectionery	Confectioners' Jour. Sc. Amer., XLII, 72.
1880..		Glucose from rags	Rev. Ind. Sc. Amer., XLII, 200.
1880..		Adulteration of sugar and candy	Dingl., J., CCXXXV, 140.
1881..	Allihn	Saccharification of starch at high temperature.	J. Pharm. (5), III, 588; J. pr. Ch. (2), XXII, 46; Z. Anal. Ch., XX, 452.
1881..	Böttinger	The sugar of oak-bark tannin	Berl. Ber., XIV, 2390, 1596; J. R. Ch., IX, 454; J. B., 1881, 992.
1881..	Boutroux	A new fermentation of glucose	J. Pharm. (5), III, 347.
1881..	Casamajor	Detection of starch sirup in sugar-house molasses.	J. Am. Ch. Soc., II, 429; Ch. News, XLIV, 265; Pol. Notizbl, XXXVI, 32; Z. Anal. C., XXI, 144; XXII, 280; Arch. Pharm. (3), XIX, 393; J. Pharm. (5), III, 349; J. r. Ch., IX, 452.
1881..	Degener	Reducing power of different sugars	Zeit. Ver. Rübenz, 1881, 349; C. C., 1881, 470; Berl. Ber., XV, 396; J. B., 1881, 980.
1881..	Delarne	Conversion of starch into sugar by oxalic acid.	C. C., 1881, 404; J. B., 1881, 987.
1881..	Dubrunfaut	Converting starch into maltose by malt extract, "maltase."	Ch. Zeit., VI, 1091; Wag., J. B., 1881, 583.
1881..	Dudley	Basic nitrate of bismuth test	Am. Ch. J., II, 47; Berl. Ber., XIV, 1121; Z. Anal. C., XX, 117.
1881..	Emmerling	A reducing substance formed by the action of KHO on fused glucose.	Pflüg. Arch., XXIV, 184; Berl. Ber., XIV, 1005; J. R. Ch., IX, 452; J. B., 1881, 983.
1881..	Fresenius	Reaction of different sugars on copper solutions, also Hg.	Z. Anal. Ch., XX, 425; Z. Anal. Ch., XX, 447.
1881..	Gayon	Research on formation of reducing sugar in cane sugar.	Ann. Agronomique; J. Pharm. (5), V, 440.
1881..	Habermann and Hönig	Action of copper hydrate on certain sugars.	Monatsch. Ch., III, 651; Z. Anal. C., XX, 565; Wien. Akad. Ber, 1881, 18; C. C., 1881, 119; Berl. Ber., XV, 2624; J. R. Ch., IX, 451; J. B. 1881, 981.
1881..	Herzfeld	Maltose	Ber. physiol Lab. Halle, IV, 15; Sc. Am. Sup., XI, 4323; Wag., J. B., 1882, 685.
1881..	Jungfleisch and Lefranc.	Levulose from inulin	C. R., XCIII, 547; J. Pharm. (5), IV, 437; C. C., 1881, 724; Dingl., J., CCXLIII, 86.
1881..	Kretschmar	Estimating glycogen, dextrine, and starch.	Pflüg. Arch., XXIV, 184; Z. Anal. C., 1881, 601; J. B., 1881, 1213.

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1881..	Külz	Sugar in urine after taking acids	Berl. Ber., XIV, 367.
1881..	Kunheim	Removing gypsum with barium oxalate.	Ch. Ind., IV, 389.
1881..	Leube	Changes that cane sugar undergoes in the stomach.	Arch. path. Anat., LXXXVIII, 222; N. Y. Med. J., XXXVI, 444; Berl. Ber., XV, 1347.
1881..	Langbeck	Bitter substances developed during fermentation.	Sci. Amer., 1881, May 21.
1881..	Lippmann	Presence of saccharine in osmosed sugar.	J. Pharm. (5), III, 65; Berl. Ber., XIII, 1826.
1881..	......do	Cane sugar inverted by carbonic acid.	J. Pharm. (5), III, 63; Berl. Ber, XIII, 1822; Z. Anal. C., XXII, 117.
1881..	Maumené	Inverting sugar with carbonic acid.	Bull. Soc. Chim. (2), XXXVI, 652; Berl. Ber., XV, 252.
1881..	Von Mering	Grape sugar from starch by means of diastase.	Z. Phys. Ch., V, 185; J. B., 1881, 1144.
1881..	Meissl	Maltose	J. pr. Ch. (2), XXV, 114; Z. Anal. C., XXII, 114; Berl. Ber., XV, 944.
1881..	Musculus and Meyer	Converting glucose into gamma dextrine with sulphuric acid.	C. R., XCII, 528; Berl. Ber., XIV, 850; C. C., 1881, 315; Dingl. J., CCXLI, 78; Bull. Soc. Chim. (2), XXXV, 368; Ch. News, XLIV, 94; Z. Anal. C., XXI, 577; Z. physiol Ch., V, 122; J. R. Ch., IX, 453; J. B., 1881, 985; Wag., J. B., 1881, 582.
1881..	Nessler and Barth	Optical action of pure and of sugared wines.	Z. Anal. C., XXI, 53.
1881..	Nessler	Composition and unwholesomeness of potato sugar.	Landw. Versuch. stat., XXVI, 207; Zeit. für. Brauwesen, 1881, 123; Z. Anal. C., XX, 466.
1881..	Musculus and Meyer	Achroö-dextrine and erythro-dextrine, a mixture of soluble starch with dextrine.	Z. phys. Ch. IV., 451; C. C. (3), XI, 809; Z. Anal. C., XXI, 577.
1881..	......do	Converting grape sugar into dextrine.	Z. phys. Ch., V, 122; C. R., XCII, 528; Bull. Soc. Chim. (2), XXXV, 368; C. C., 1881, 315; J. B., 1881, 985.
1881..	Nencki and Sieber	Decomposition of grape sugar and uric acid by alkali, at 35° to 40° C.	Berl. Ber., XV, 83, 2747; J. pr. Ch. (2), XXIV, 498; XXVI, 1.; Ch. News, XLV, 87; J. Pharm. (5), VI, 313; J. B., 1881, 1032.
1881..	Nessler	Injurious effects of potato starch on the health.	Landw. Vers. Stat., XXVI, 207; Pol. Notizbl, XXXVI, 1; Ch. Zeit Sc. Amer., XLV, 128; Monit. Scientif., XXIII, 494; Z. Anal. C., XX, 466.
1881..	Pellet	Estimating crystalline sugar in solution with glucose and dextrine.	C. R., XCI, 308; Z. Anal. C., XX, 125.
1881..	Pfeiffer and Tollens	Compounds of alkalies with carbohydrates.	A. C. P., CCX, 285.
1881..	Roux	A yeast cell that causes fermentation in glucose and milk sugar.	Bull. Soc. Chim. (2), XXXV, 371; J. B., 1881, 1146.
1881..	St. Danziville	Glucose for alcohol, from wood	Ch. Zeit., 1881, 92; J. B., 1881, 1303.
1881..	Salomon	Specific gravity, reducing power, and optical properties of grape sugar solutions.	Rep. Anal. Ch., 1881, 309; Berl. Ber., XIV, 2710; J. R. Ch., IX, 451; J. B., 1881, 982.
1881..	Schlossing	Action of glucose towards nitrogen	A. c. p. (5), XXIV, 284; Berl. Ber., XIV, 2579.
1881..	Schumacher-Kopp	Adulteration of honey	Ch. Zeit., 1881, 646; J. B., 1881, 1303.
1881..	Schmidt	Sugar gives no reaction with fuchsine decolorized by SO_2.	Berl. Ber., XIV, 1850.
1881..	Schützenberger	Glucose carbonic acid from invert sugar.	Bull. Soc. Chim. (2), XXXVI, 144; Berl. Ber., XIV, 2274.
1881..	Seegen and Kretschmar.	Sugar formed in the liver	Pflüg. Arch., XXIV, 467; Berl. Ber., 1881, 1575; J. B., 1881, 1038.
1881..	Soxhlet	Pure anhydrous starch sugar	Dingl., J., CCXLV, 121; Z. Anal. C., XX, 429.
1881..	......do	Estimating maltose	Z. Anal. C., XX, 440.
1881..	......do	Action of sugar towards alkaline, copper, and mercury solutions.	J. Pr., Ch. (2), XXI, 227; Z. Anal. C., XX, 425.
1881..	Sundwik	Specific rotatory power of maltose	Zeit. phys. Ch., V., 427; Wag., J. B., 1881, 583.
1881..	Valente	Synthesis of glucose. Reply to Professor Zuino.	Gazz. Chim. Ital., XI, 52; Berl. Ber., XIV, 542; Berl. Ber., XIII, 2431.
1881..	West Knight	Action of dextrine toward maltose in worts.	Analyst., VII, 81, 211; Berl. Ber., XVI, 438.

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1881	Wiley	Glucose and grape sugar	Pop. Sci. Mo., XIX, 251.
1881	Von Wagner-Frankel.	A practical treatise on the manufacture of starch, starch sugar, and dextrine.	Philadelphia, 1881.
1881..	Yoshida	Maltose, from Japanese Amé	Ch. News, XLIII, 29, 54; J. B., 1881, 984.
1881..		Cassava, a new source of glucose..	Sc. Amer., XLV, 415; XLVI, 121; Confectioner's Journal.
1881..		Glucose sirup, a deadly poison	Sugar cane, XIII, 367.
1881..		Is glucose wholesome?	Sc. Amer., XLIV, 128.
1882..	Allihn	Reducing power of grape sugar for copper is not constant.	N. Zeit., Rübenz, IX, 317; Zeit. Ver. Rübenz, 1882, 608, 865; Ch. Zeit., VI, 995; Wag., J.B., 1882, 691.
1882..	Bauer	Influence of invertine on fermentation of cane sugar.	Org. Oestr. Ver. Rübenz. Dingl., J., CCXLV, 47.
1882..	Behr	Cryst. anhydrous grape sugar	Berl. Ber., XV, 1104; Ch. News, XLV, 179; Sc. Amer. sup., XIII, 5378; Am. J. Pharm., 1882; J. Pharm. (5), VI, 514; VII, 45; Dingl., J. CCLV, 121; Wag., J. B., 1882, 689.
1882..	Binz	Injurious effects of potato brandy.	Centr. Allgem. Gesund, 1882, 131.
1882..	Bleile	Conversion of cane sugar by hydrochloric acid and by the gastric juice.	Med. News., XLI, 650.
1882	Boiret	Fehling's solution	L'Union Pharm.; J. Pharm. (5), V, 427.
1882	Casamajor	Detecting starch sugar in molasses.	J. Am. Ch. Soc., III, 87; Berl. Ber., XV, 1775; Sc. Amer. Sup., XIII, 5026.
1882	Chandler & Ricketts..	Determination of artificial grape or starch sugar in cane sugar.	2d Ann. Report, State Board of Health, N. Y., 1882.
1882	Cuisinier	Compound of maltose with lime...	La Sucrerie ind., XIX, 244, 278; Wag., J. B., 1882, 696.
1882	......do	Newly observed property of glucose; its reducing power.	Sc. Amer., XLVII, 23; Monit. Scient., 1882, 150; Ch. Zeit., VI, 474.
1882	Degener	Fluctuations in reducing power of sugars.	Zeit. Ver. Rübenz., XVIII, 349; Z. Anal. C., XXII, 444.
1882	......do	Personal error in polarizing	Ver. Rübenz., Ind., 1882, 642; Dingl., J., CCXLVII, 165.
1882	Detmer	Use of citric acid when converting starch with diastase.	Zeit. Phys. Ch., VII, 1; Wag, J. B, 1882, 686.
1882	Dubrunfaut	Starch sugar	Ch Zeit., VI., 326; Sc. Amer., XLVI, 313.
1882	Gall	Rotatory power of glucose	Monit. Scientif., Dec., 1882; Ch. News, XLVI, 292.
1882	Hehner	On Pavy's copper solution	Analyst., VI, 218; Z. Anal. C., XXII, 447.
1882	Habermann and Hönig	Action of cupric hydrate upon sugars.	Wien. Akad. Ber., 1882, 657; Ch. Zeit., VI, 1050.
1882	Hesse	Anhydrous grape sugar	Berl. Ber., XV, 2349; Ch. Zeit., VI, 1252.
1882	Hölzer	Sources of error in polarizing	Berl. Ber., XV, 1932; Dingl., J., CCXLVI, 345; Z. Anal. C., XXII, 237.
1882	Kiliani	Lactic acid from dextrose	Berl. Ber., XV, 136.
1882	......do	Saccharone and saccharine	A. C. P., CCXVIII, 361; Berl. Ber., XV, 701, 2953; Berl. Ber., XVI, 2294; Dingl., J., CCXLV, 191; CCXLVII, 435; Zeit. Anal. Ch., XXII, 267.
1882	Lebaigne	Optical estimation of glucose	Rep. Pharm., XXXVIII, 391; Ch. Zeit., VI, 1205; Wag. J. B., 1882, 692.
1882	Leplay and Cuisinier..	Preparation of maltose	Dingl., J., CCXLVII, 267.
1882	Lowitz	Discovery of grape sugar	Sc. Amer., XLVII, 409; (Crell.)
1882	Marcano	Direct fermentation of starch	C. R., XCV, 856; J. Pharm. (5), VII, 168; Ch. Zeit., VI, 1285.
1882	Moritz	End of Fehling's reaction in very dilute solutions.	Z. Anal. C., XXII, 43; Berl. Ber., XVI, 487.
1882	Müller, W	Preparation of grape sugar by Neubauer's method.	J. pr. Ch. (2), XXVI, 78; Amer. Ch. J., IV, 296; Wag. J. B., 1882, 690

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1882	Nessler and Barth	Testing for potato sugar in urine.	Z. Anal. C., XXI, 53.
1882	Otto	Preparation of grape sugar and titrating with Knapp's test.	J. pr. Ch., (2), XXVI, 87; Ch. News, XLVI, 208.
1882	Perrey	Origin of saccharine matter in plants.	C. R., XCIV, 1124.
1882	Robin	Sugar in urine	Monit. Scientif., July, 1882; Ch. News, XLVI, 78.
1882	Soxhlet	Saccharification of starch	Sc. Am. Sup., XIII, 5378.
1882	Sidersky	Estimating invert sugar	Z. Ver. Rübenz., 1882, 779; Ch. Zeit., VI, 1253.
1882	Wiley	Investigations on starch sugar	Ch. News, XLVI, 175; Dingl., J., CCXLVII, 378; Ch. Zeit., VI, 1206; Wag., J. B., 1882, 692.
1882	Wolff	Testing for starch sugar in sirups	Pharm. Centrlb., XXIII, 491; Dingl., J., CCXLVII, 228; Z. Anal. C., XXII, 280.
1882	Zincke	Constitution of glucose and fruit sugar.	A. C. P., CCXVI, 318.
1883	Antweiler and Breidenbend.	Estimation of diabetic sugar by fermentation.	Pflüg. Arch., XXVIII, 179; Z. Anal. C., XXII, 143; Ch. N., XLVII, 179.
1883	Bourquelot	Researches on physiological properties of maltose.	C. R.; Le Genie Civil, IV, 82.
1883	Carles	Cane sugar better than glucose for making wine.	J. Pharm. (5), VII, 14; Ch. News, XLVII, 35.
1883	Casamajor	Simple test for glucose in sugar.	Sc. Amer., XLVIII, 217.
1883	Chittenden and Ely	Alkalinity and diastatic action of human saliva.	Am. Chem. J., IV, 329; Berl. Ber., XVI, 974.
1883	Eitner	No grape sugar in leather	Gerberz, 1883, 31; Dingl., J. CCXLVIII, 218.
1883	Faulenbach	Estimation of grape sugar and starch in food with Fehling's solution.	Z. physiol. C., VII, 510; Berl. Ber., XVI, 2322.
1883	Flechsig	Cellulose sugar	Z. physiol. C., VII, 523; Berl. Ber., XVI, 2508.
1883	Gladstone and Tribe	Action of light and heat on cane and invert sugars.	J. Ch. Soc., 1883, 341; Berl. Ber., XVI, 2509.
1883	Haas	Comparison of Fehling's, Sachsse's and optical methods.	Z. Anal. C., XXII, 215; Berl. Ber., XVI, 1112; Ch. News, XLVII, 247.
1883	Herzfeld	Maltose	A. C. P., CCXX, 206.
1883	Johnson, G. S	Ammonio-cupric method	Ch. News, XLVII, 57.
1883	Keating	Salivary digestion of starch by infants.	Med. News; Drug. Circ., 1883, p. 172.
1883	Lagrange	Glucose and invert sugar precipitated by lead salts.	C. R., XCVII, 857; Berl. Ber., XVI, 2775; Ch. Zeit., 1883.
1883	Von Mering	Is glucose wholesome?	Sc. Amer., XLVIII, 161; Vierteljahr Gesundheitspflege, 1882.
1883	Müller Thurgau	Transformation of starch into sugar at low temperature in plants.	Ann. agronom; J. Pharm. (5), VII, 508.
1883	Otto Lorenz	Manufacture of potato starch	Pract. Mach. Constr., 1883.
1883	Petzholdt	Diazo-benzol-sulpho-acid test for grape sugar.	Berl. Klin Wochensch, 1883, No. 14; Z. Anal. C., XXII, 466.
1883	Salomon	Starch and its changes under the influence of organic and inorganic acids.	J. Pr. Ch., XXVIII, 82; Berl. Ber. XVI, 2509; Ch. Zeit., VII, 1193.
1883	Scheibler	Saccharine	Berl. Ber., XIII, 2212.
1883	Sonnerat	Cupric solutions for estimating glucoses.	J. Pharm. (5), VIII, 28.
1883	Soxhlet	Refining and crystallizing starch sugar.	Sc. Amer. Sup., XV, 5985.
1883	Tollens	Action of dextrose towards ammonio-silver solutions.	Berl. Ber., XVI, 921.
1883	Scheibler	Formation of saccharine from glucoses.	Berl. Ber., XVI, 2434.
1883	Urech	Inversion of saccharose	Berl. Ber., XVI, 762.
1883	Vivien	Estimation of glucose	Dingl., J., CCL. 133; Sucrerie Ind., XXI, 3; Berl. Ber., XVI, 2775; Sc. Amer., XLVIII, 217.
1883	Zulkowsky	Estimating sugar	Ber. Oestr. Ch. Ges., 1883, 39; Dingl., J., CCL, 133; Berl. Ber., XVI, 2775.
1883		Manufacture of glucose in America.	Ch. Zeit, VII, 1212.

APPENDIX 6.

REPORT ON GLUCOSE—Continued.

PATENTS RELATING TO THE MANUFACTURE OF STARCH AND STARCH SUGAR.

No.	Date.	Patentee.	Title.	Method.
12846	May 8, 1855	H. V. Duryea	Starch rake	Specifications not printed.
22789	Feb. 1, 1859	W. Duryea	Making starch	Do.
28278	May 15, 1860	C. S. Irwin	Cleansing starch	Do.
40693	Nov. 24, 1863	T. Kingsford	Starch machine	Do.
42358	Apr. 19, 1864	W. Duryea	Removing starch	Do.
42727	May 10, 1864	F. W. Gossling	Improved manufacture of sugar	Soak the corn a week, crush it and soak again, wash with alkali, convert with sulphuric acid, heat with worm of lead pipe.
42728	May 10, 1864	F. W. Gossling	Making sugar	Specifications not printed.
43047	June 7, 1864	M. Thompson	Treating grain for distillation	Do.
49012	July 25, 1865	H. A. Tilden	Improvement in manufacture of sirup from corn	Treats the entire grain with sulphuric acid at 220° Fahr.
55629	June 19, 1866	H. I. Diessner	Improvement in making sirup from corn	Adds barley-malt, sugar, and wheat-flour.
56356	July 17, 1866	John Briggs	Improved apparatus for preparing starch and size.	
58824	Oct. 16, 1866	A. H. Hirsh	Improvement in manufacture of sugar from corn	Softens the corn with dilute acid at 170° F. to remove gluten, then crush, sieve, wash with dil. ammonia, convert with sulphuric acid, neutralize with sulphate of alumina.
60370	Dec. 11, 1866	T. Hawkes	Condensed extract of malt	Evaporated in vacuo.
60630	Dec. 18, 1866	Leopold Hoff	Improved malt extract	Uses decoction of fennel.
64139	Apr. 23, 1867	Narcisse Pigeon	Improvement in manufacture of starch sugar	Converts with 1 per cent. sulphuric acid at 300° Fahr.
65664	June 11, 1867	J. J. Gilbert	Improvement in manufacture of starch	
66121	June 25, 1867	C. H. Blanchard	Improved machine for making starch paste, size, &c	
67514	Aug. 6, 1867	A. Erkenbrecher	Improved starch elevator	
67515	Aug. 6, 1867	......do	Improved starch-making apparatus	
67516	Aug. 6, 1867	......do	Improved starch agitator	
68294	Aug. 27, 1867	......do	Improved apparatus for drying starch	
68374	Sept. 3, 1867	Mason & Brant	Improved machine for stirring starch	
73259	Jan. 14, 1868	J. A. Owens	Improved starch-making apparatus	
78320	May 26, 1868	J. A. Owens	Improved starch trays	
81880	Sept. 8, 1868	C. Gilbert	Improved starch separator	
87758	Mar. 16, 1869	William Clough	Improvement in defecating saccharine fluids	Uses ground sulphate of baryta and coagulates by heat.
87759	Mar. 16, 1869	......do	Improvement in refining and decolorizing saccharine liquids.	Hydrate of alumina and waterglass employed.
87980	Mar. 16, 1869	Sims & Hutchinson	Improved mode of preparing grain for distillation	Removes oils by carbon di-sulphide.
94341	Aug. 31, 1869	J. J. Ridge	Improved process and apparatus for treating flour and meal.	Farinaceous substances are roasted at 212° F. for six hours and mixed with an alkaline or saccharine substance.
101783	Apr. 12, 1870	S. Stenberg	Manufacture of sugar and alcohol from lichens	Boiling with dilute acids.
109991	Dec. 6, 1870	C. Delamarre	Sugar from sweet potatoes	Malted barley added to the paste heated to 180° F., then to 220°, and cold water added.
113997	Apr. 25, 1871	C. H. Fringes	Improvement in preparing and mashing grain	Treated with dilute alkali which is neutralized with H Cl.
115051	May 23, 1871	J. J. Grosheinz	Improvement in manufacture of glucose sirups and sugars.	Uses dilute hydrochloric or sulphuric acid, and neutralizes with soda, potash, magnesia, &c.

118523	Aug. 29, 1871	W. Garton	Preparation of fermentable saccharine matters	Neutralizes with finely-ground animal charcoal or phosphate of lime.
118524	Aug. 29, 1871	do	Manufacture of invert sugar for brewing, &c	Adds dilute sulphuric acid to saccharine juices and heats to 160° or 212° F., then adds animal charcoal.
127418	June 4, 1872	W. H. Keyt	Improvement in manufacture of glucose	Converts starch at low temperature (220° F.) and neutralizes with lime.
135904	Feb. 18, 1873	C. Gilbert	Improvement in manufacture of starch	
137911	Apr. 15, 1873	do	Improvement in starch apparatus	
137911	Apr. 15, 1873	do	Improvement in starch mills	
140141	June 24, 1873	T. Kingsford	Improvement in starch apparatus	
140141	Aug. 5, 1873	do	do	
145213	Dec. 2, 1873	do	do	
145846	Dec. 23, 1873	O. F. Cook	Improvement in processes of preparing grain for flour	
156802	Nov. 10, 1874	W. A. Lawrence	Improvement in composition of hop extract for flavoring beer.	Mix hop extract glycerine, grape sugar and cane sugar.
159837	Feb. 16, 1875	E. E. Pearse	Improvement in manufacture of grape sugar	Converting rice and other grain into glucose or grape sugar by one operation in a vessel containing dilute sulphuric acid.
166090	July 27, 1875	W. Garton	Improvement in manufacture of glucose	Rice, &c., is converted by acid and heat, and instead of neutralizing the excess of acid is used to invert cane sugar.
167224	Aug. 31, 1875	L. Chiozza	Improvement in treating maize	Immerses the grain in sulphurous acid before crushing and screening.
172099	Jan. 11, 1876	E. E. Duryea	Improvement in drying starch	
186935	Feb. 6, 1877	S. H. Johnson	Improvement in manufacture of glucose	"Permeable" grain made by treating with dilute hydrochloric acid, wash, drain, macerate with acid again, then submitted to the direct action of steam under pressure.
187250	Feb. 13, 1877	Boomer & Randall	Improvement in manufacture of malt sirups or extracts	Fatty acids removed by alkali.
187813	Feb. 13, 1877	H. R. Randall	do	Washing ground grain at 180° F., then mixing it with malt at 158° to 160°.
187747	Feb. 27, 1877	do	Improvement in saccharine composition sirup	A mixture of uncrystallizable glucose with sucrose.
187881	Feb. 27, 1877	A. Manbre	Improvement in apparatus and processes for manufacturing purified saccharine solutions.	Removes fatty matter by distilling it off after mixing with dilute acid.
191942	June 12, 1877	R. d'Heureuse	Preparing mash	Uses a high pressure, without raising the temperature, so as to injure the diastase, say 140° to 175° F.
195718	Oct. 2, 1877	F. Melkersman	Improvement in drying and purifying starch by centrifugal action.	
198192	Dec. 18, 1877	R. d'Heureuse	Process and apparatus for disintegrating cereals	
198474	Dec. 25, 1877	R. S. Toothill	Process for manufacture of sirups	Mashing ground corn or other cereal with barley malt.
202832	Apr. 23, 1878	T. Kingsford	Process and apparatus for drying starch	
203935	May 21, 1878	Narcisse Pigeon	Improvement in process for manufacturing glucose	Adds diastase to the corn mash at 125° F., then heats to 185° F., then cool to 152°, and adds more diastase.
210496	Dec. 3, 1878	J. Carnick	Improvement in malt extracts	Malt barley, wheat, and oats separately; mix; evaporate in vacuo at 120° F.
213320	Mar. 18, 1879	G. Burkhardt	Processes for manufacturing starch	
214910	Apr. 29, 1879	L. G. Hegi	Improvement in starch compounds	Adds sulphate of ammonia, sugar, and acetic acid.
218020	July 29, 1879	H. M. Hartshorn	Improvement in processes for manufacturing glucose	Corn is granulated dry, sifted, ground to meal, and converted by diastase or acid.
220116	Sept. 30, 1879	Behr and Humphrey	Extracting oil from the residuum of glucose	The starch first removed leaves the fat in the residuum, which is extracted with bisulphide of carbon.
220150	Sept. 30, 1879	H. C. Humphrey	Improvement in manufacture of glucose	Direct treatment of the corn with an organic acid.
220825	Oct. 21, 1879	G. A. Gessner	Producing malt extract	A heated, extractive liquid percolates through the hot grain.
223847	Jan. 27, 1880	J. F. Gent	Prepared cereal	

APPENDIX 6.—*Patents relating to the manufacture of starch and starch sugar*—Continued.

No.	Date.	Patentee.	Title.	Method.
226398	Apr. 13, 1880	C. Furbish	Process of manufacturing glucose	The corn is cracked and hulled, the hulls and clippings removed, and the hard portion subjected to heat, water, and pressure. It is then converted by diastase or acid under pressure.
226434	Apr. 13, 1880	J. F. Wolff	......do	Currents of air or oxygen forced through the mass while mashing, boiling, and neutralizing.
230991	Aug. 10, 1880	L. J. Bennett	Process of obtaining the glutinous and starchy substances from Indian corn.	Beating or whipping off the glutinous portion or hull.
231804	Aug. 31, 1880	H. C. Humphrey	Obtaining starch and glucose from corn	Part of the starch is separated and sold, the remainder converted into glucose.
235053	Nov. 30, 1880	T. Gassaway	Manufacture of starch	
236330	Jan. 4, 1881	R. d'Heureuse	Manufacture of glucose	The corn, freed from hulls and germs, is steeped, and the solution of gluten expelled in centrifugal machine. It is converted with acid, neutralized with lime, then oxalic acid and soda added.
238474	Mar. 1, 1881	C. O'Sullivan	Treatment of starchy substances, and production of a substitute for malt in brewing, and called "dextrine maltose."	Starch treated with sulphuric acid, and the conversion stopped when there is 44% of glucose, as found by Fehling's method.
239171	Mar. 22, 1881	T. A. & W. T. Jebb	Obtaining starch from grain	
240651	Apr. 26, 1881	A. L. Bruce	Treatment of dextrine, maltose, &c., and apparatus	Apparatus for drying the products, so that they can be pulverized when cold.
240652	Apr. 26, 1881	A. L. Bruce	Machinery for treating dextrine, maltose, &c.	
240796	Apr. 26, 1881	H. Williams	Process and apparatus for manufacturing grape sugar (to make it crystallise).	Artificially cools and agitates the sirup after it leaves the vacuum pan, then adds a creamy solution of grape sugar.
240907	May 3, 1881	T. A. & W. T. Jebb	Apparatus for steeping grain	
241202	May 10, 1881	A. G. Fell	Manufacture of glucose	Corn treated with nitro-sulphuric acid at 195° F. to 214° F. It is boiled in vacuum pans, and sulphurous acid gas introduced.
241476	May 17, 1881	F. Camus	Treating cereals to separate oily germs, flour and starch	
241666	May 17, 1881	T. A. & W. T. Jebb	Obtaining starch from Indian corn	
241903	May 24, 1881	Williams & Alberger	Manufacturing crystallizable grape sugar	One per cent. of finely-powdered grape sugar added.
242207	May 31, 1881	Lyon & Taylor	Machine for pulverizing grape sugar	
*9732	May 31, 1881	J. A. Owens	Manufacture of starch	
242439	June 7, 1881	A. P. Dubrunfaut	Saccharification of amylaceous matters by malt	Starch paste treated with an exhausted infusion of malt at 122° F. for 60 or 70 hours. Oxidized malt infusions are more active.
243024	June 14, 1881	E. Wilhelm	Starch separator	
243269	June 21, 1881	T. A. & W. T. Jebb	Starch table	
243270	June 21, 1881	T. A. & W. T. Jebb	Starch apparatus	
243310	June 21, 1881	C. Sheibler	Separating gypsum from solutions of starch sugars	The use of barium oxalate.
243669	June 28, 1881	Williams & Alberger	Process of manufacturing glucose from grain	Cancelled, sec. 246, 262.
244902	July 26, 1881	S. H. Johnson	Production of saccharine substances containing little or no starch.	Dilute hydrochloric acid employed, and steam at a pressure of 60 to 90 lbs., or water at 305° F.
245840	Aug. 9, 1881	A. Behr	Apparatus for manufacturing starch liquor	
246262	Aug. 23, 1881	Williams & Alberger	Glucose from grain	At first only enough acid is used to produce soluble dextrine and coagulate gluten and albumen; filter, then convert with acid. Residue used as cattle food.
*9850	Aug. 23, 1881	......do	Process of manufacturing crystallizable grape sugar	The same as 241903 above.

246671	Sept. 6, 1881	R. W. Graves	Starch table	
246816	Sept. 6, 1881	Porion & Méhay	Utilizing residua of the acid treatment of grain for manufacture of alcohol.	**If the residues are fed to cattle purify the hydrochloric acid and use pure carbonate of soda.**
247152	Sept. 20, 1881	A. Behr	Process of treating corn in the manufacture of starch, glucose, &c., from it.	**It automatically separates the corn and water into three parts germs alone; hulls; mealy part.**
247153	Sept. 20, 1881	......do	Apparatus for the above	**Do.**
247288	Sept. 20, 1881	J. L. Alberger	Process of manufacturing sugar from corn	**Grain or meal treated with hot water and steam only until the starch is converted into a solution of soluble dextrine, filtering, converting with acid or malt-liquor.**
247433	Sept. 20, 1881	W. G. Taylor	Apparatus for siphoning starch liquor	
247455	Sept. 20, 1881	Williams & Alberger	Refining glucose or grape sugar	**Its bitter element is eliminated by fermenting it after saccharification.**
247957	Oct. 4, 1881	F. Soxhlet	Refining starch sugar	**The sirup mixed with ethyl or methyl alcohol and pulverized grape sugar.**
247958	Oct. 4, 1881	......do	Refining and crystallizing starch sugar (anhydrous)	**Crystallizes a mixture of starch sugar and wood spirit at 30 to 35° C. (86 to 95° F.)**
248313	Oct. 18, 1881	F. Higel	Glucose from the cassava plant	**Converts with sulphuric acid, and neutralizes with sea shells.**
248734	Oct. 25, 1881	R. W. Graves	Starch table	
248904	Nov. 1, 1881	Wilson & O'Reilly	Gum substitute	**Starch is moistened with hydrochloric acid, dried and heated evenly, or roasted.**
248972	Nov. 1, 1881	Williams & Alberger	Manufacturing glucose or grape sugar	**It is converted into dextrine and filtered before saccharification.**
248973	Nov. 1, 1881	......do	Apparatus for starch or starch sugar	
249056	Nov. 1, 1881	T. A. Jebb	Starch separator	
250084	Nov. 29, 1881	S. M. Lillie	Process of and apparatus for mixing glucose with cane sugar.	**A moist sugar is obtained by spraying a solution of grape sugar on dry cane sugar in the revolving machine, slacking its speed.**
250117	Nov. 29, 1881	Weber & Scovell	Manufacture of glucose from seeds of sorghum, imphee, &c.	**Uses sulphuric acid in open or closed converters.**
*9947	Nov. 29, 1881	L. Chiozza	Process of treating maize	**Steeping in sulphurous acid before crushing it.**
250143	Nov. 29, 1881	R. W. Graves	Machine for reducing starch	
250333	Dec. 6, 1881	A. Behr	Manufacturing crystallized anhydride of grape sugar from watery solution.	**A mass containing about 15 per cent. of water is kept at 100° Fahr. for 12 to 24 hours, then centrifugalled.**
250334	Dec. 6, 1881	......	Refining grape sugar.	**See above.**
250335	Dec. 6, 1881	Behr & Humphrey	Manufacture of starch and sirup or sugar from corn	**The overflow from the starch tables treated with acids to saccharify the starch.**
250362	Dec. 6, 1881	H. C. Humphrey	Method of settling starch liquor	
251827	Jan. 3, 1882	G. Burkhardt	Method and apparatus for obtaining starch	
251887	Jan. 3, 1882	H. C. Humphrey	Treating maize in manufacture of beer, glucose, &c	**First makes soluble starch with acid, separates germs and hulls, then converts it.**
253337	Feb. 7, 1882	A. Atkinson	Machine for starch	
253919	Feb. 21, 1882	Giesecke & Hamlin	Process of manufacturing corn sirup	**Heats a mixture of cane and grape sugar and agitates it.**
253923	Feb. 21, 1882	H. Hamlin	Art of manufacturing starch	
254029	Feb. 21, 1882	C. Lautz	Starch table	
254063	Feb. 21, 1882	M. J. Stark	......do	
254157	Feb. 28, 1882	E. Roat	Apparatus for washing starch	
254158	Feb. 28, 1882	......do	Starch machinery	
254159	Feb. 28, 1882	...... do	Apparatus for cooling sirups	
254240	Feb. 28, 1882	Roat & Hamlin	Process and apparatus for treating starch refuse	**The wet material is subjected to pressure, disintegration and heat to prepare it for cattle feed.**
254329	Feb. 28, 1882	W. T. Jebb	Method and apparatus for manufacturing distilled spirits.	**Grain mashed with malt and fermented.**
254330	Feb. 28, 1882	......do	Distilled spirits from grain	

*Reissue.

APPENDIX 6.—*Patents relating to the manufacture of starch and starch sugar*—Continued.

No.	Date.	Patentee.	Title.	Method.
254359	Feb. 28, 1882	E. Roat	Apparatus for manufacturing starch	
256221	Apr. 11, 1882	T. A. & W. T. Jebb		
256315	Apr. 11, 1882	Graves & Heede	Starch separator	
256622	Apr. 18, 1882	A. Behr	Crystallized anhydrous grape sugar	A longer time allowed for crystallizing at 90° F.
256623	Apr. 18, 1882	do	Crushed anhydrous grape sugar	
256630	Apr. 18, 1882	W. T. Booth	Starch separator	
256809	Apr. 18, 1882	E. Roat	Crystallizing apparatus for grape sugar	
256835	Apr. 25, 1882	H. Hamlin	Purifying glucose	Two concentrations with intervening filtration.
257930	May 16, 1882	E. Fox	Manufacture of glucose	Filters out gluten before saccharification; agitates with air.
257958	May 16, 1882	F. O. Matthiessen	Washing out starch troughs	
257959	May 16, 1882	Matthiessen & Behr	Apparatus for emptying starch tables	
258070	May 16, 1882	T. A. & W. T. Jebb	Starch apparatus	
258265	May 23, 1882	J. J. Tonkin	Starch settling tanks	
259050	June 6, 1882	Roat, McKee & Hamlin	Converter for starch into glucose	
260380	July 4, 1882	J. & F. Fermenich	Starch washer	
260853	July 11, 1882	J. Duff	Obtaining dextrine and saccharine matter from grains	Grind, mash, regrind, separate hulls, then finish the conversion.
261445	July 18, 1882	P. H. Grimm	Starch separator	
263030	Aug. 22, 1882	W. Duryea	Starch apparatus	Pressed, heated, ground, and then mixed with ground grain for cattle feed.
263525	Aug. 29, 1882	W. T. Jebb	Treating starch refuse	
263958	Sept. 5, 1882	E. S. Renwick	Manufacture of starch	
264037	Sept. 5, 1882	T. A. Jebb	Manufacture of dry grape sugar	Agitate and cool the liquid, and expose to air currents.
264222	Sept. 12, 1882	H. W. Bartol	Manufacture of glucose	Removes oils and gluten by soaking in acid or alkali at 90° to 120° F.
264688	Sept. 19, 1882	P. H. Grimm	Starch separator	
266136	Oct. 17, 1882	do	do	
266268		W. B. Brittingham	Glucose from cactus	Uses diastase.
267546	Nov. 14, 1882	G. Langa	Manufacture of dextrine glucose and grape sugar	Attacks starch with oxygenated glucose liquid and phosphoric acid. Neutralizes with saccharate of magnesia.
268653	Dec. 5, 1882	A. G. Fell	Manufacture of glucose	Treats the grain with acids, neutralizes and then treats with sulphurous acid under pressure.
269717	Dec. 26, 1882	W. Robinson	Method of treating grape sugar	Breaks it up and passes through the fragments a current of vapor capable of taking up the impurities.
269779	Dec. 26, 1882	H. Endemann	Manufacture of glucose and grape sugar	Orthophosphoric acid acts on starch above 212° F.
270042	Jan. 2, 1883	A. G. Fell	Manufacture of glucose	Purifies it by cooling the hot solution to precipitate the gluten, &c.
270699	Jan. 16, 1883	W. Robinson	Method of crystallizing grape sugar	Melts the sugar, but arrests the process before completely dissolved and adds 5 per cent. of water below 212° F., to form an emulsion and lets it stand at low temperature.
276334	Apr. 24, 1883	H. W. Bartol	Manufacture of glucose and grape sugar	It is converted by the dry process without separating the starch from foreign matters, uses sulphurous acid, and filters the mass over charcoal.
277320	May 8, 1883	C. C. Miller	Machine for cutting blocks of grape sugar	
278392	May 29, 1883	J. H. Brookmire	Apparatus for mixing sugars	

278562	May 29, 1883	Landry & Lauga	Methods and apparatus for converting amylaceous and ligneous substances into grape sugar.	By using oxygenated chlorine.
279354	June 12, 1883	J. W. Decastro	Converting starch into glucose	Uses carbonic acid and steam under pressure.
280045	June 26, 1883	T. P. Kingsford	Manufacture of dextrine, glucose, &c	Soak in lime water, grind, add sulphurous acid, then nitric acid, and finally steam pressure.
285067	Sept. 18, 1883	Polson & Harley	Manufacture of starch	
285654	Sept. 25, 1883	T. Norton	Process for crystallized grape sugar	A concentrated solution is cooled almost to solidification, then melted and permitted to cool and crystallize.
88245	Nov. 15, 1883	H. J. Krebs	Manufacture of glucose	Exposing the grain to acidulated water in movable vessels.

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REPORT

OF THE

NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1884.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

REPORT

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OF THE

NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1884.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

LETTER OF TRANSMITTAL.

National Academy of Sciences,
Washington, D. C., January 20, 1885.

Sir: In conformity with the requirements of the act of incorporation approved March 3, 1863, I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year.

Very respectfully, your obedient servant,

O. C. MARSH,
President of the National Academy of Sciences.

To the President of the Senate.

REPORT

OF

THE NATIONAL ACADEMY OF SCIENCES.

The National Academy of Sciences was established by act of Congress, in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

The object of the Academy is to advance science, and especially to investigate, examine, experiment, and report on any subject of science or art, whenever called upon by any Department of the Government.

The Academy contains at present about one hundred members, and these have all been selected for their original researches in science. They represent within their ranks nearly every department of knowledge, and their services, in accordance with the charter of the Academy, are always at the disposal of the Government, without compensation.

SESSIONS OF THE NATIONAL ACADEMY.

During the past year, the Academy has held three sessions. The first was the regular annual meeting, held in Washington, D. C., April 15 to 18, 1884; the second was a scientific session, in Newport, R. I., October 14 to 17, 1884; and the third was a special session, in Newport, October 15, 1884.

STATED SESSION.

HELD IN WASHINGTON CITY, APRIL 15 TO 18, 1884.

The Washington session was held in the National Museum, the president, Prof. O. C. Marsh, presiding.

The following members were present during the session:

Abbe.
Abbot.
Baird.
Barker.
Brewer.
Brush.
Coffin.
Coues.
Ferrel.
Gilbert.
Gill.
Hall, A.
Hall, James.
Hayden.
Hilgard, J. E.
Hill, G. W.
Hunt.
Langley.
Lesley.
Lyman.
Marsh.
Meigs.
Newcomb.
Newton.
Packard.
Powell.
Pumpelly.
Remsen.
Rowland.
Schott.
Scudder.
Silliman.
Trowbridge, J.
Verrill.
Wright.
Young.

The following named gentlemen were invited to attend the meetings of the Academy, and to participate in the scientific proceedings: Baron Struvé, Russian minister at Washington; Mr. John A. Ryder, of the National Museum; Mr. H. M. Paul, of the National Observatory; Dr. E. M. Gallaudet, of Washington; Prof. F. W. Clark, of Washington; Mr. J. S. Diller, of Washington.

At this session, the following papers were read and discussed:

1. GILBERT, G. K.—The Sufficiency of Terrestrial Rotation to Deflect River Courses.
2. HUNT, T. STERRY.—The Origin of Crystalline Rocks.
3. VERRILL, A. E.—Zoölogical Results of the Deep-Sea Dredging Expedition of the United States Fish Commission Steamer Albatross. Discussed by Messrs. Gill and Brewer.
4. REMSEN, IRA.—The Quantitative Estimation of Carbon in Ordinary Phosphorus.
5. HILGARD, J. E.—On the Depth of the Western Part of the Atlantic Ocean and Gulf of Mexico, with an Exhibition of a Relief Model. Discussed by Messrs. Lesley, Silliman, Powell, and Hunt.
6. HILGARD, J. E.—On the Relative Levels of the Western Part of the Atlantic Ocean and Gulf of Mexico with Respect to the Gulf Stream. Discussed by Messrs. Meigs, Gilbert, and Coffin.
7. NEWCOMB, SIMON.—On the Photographs of the Transit of Venus taken at the Lick Observatory. Discussed by Messrs. Langley and Young.
8. REMSEN, IRA.—Reduction of Halogen Derivatives of Carbon Compounds.
9. LANGLEY, S. P.—The Character of the Heat Radiated from the Soil. Discussed by Messrs. Young and Newcomb.
10. COPE, E. D.—On the North American Species of Mastodon. Read by Mr. Gill.
11. GILL, THEO., and RYDER, JOHN A.—The Characteristics of Lyomerous Fishes.
12. BARKER, GEORGE F.—On the Fritts Selenium Cell. Discussed by Mr. Langley.
13. BARKER, GEORGE F.—On a Lantern Voltameter.
14. BRUSH, GEORGE J.—On the Occurrence of Mercury in Native Silver from Lake Superior. Discussed by Mr. Silliman.
15. SILLIMAN, B.—On the Existence of Tin Ore in the Older Rocks of the Blue Ridge. Discussed by Mr. J. E. Hilgard.
16. LOOMIS, ELIAS.—Reduction of Barometric Observations to Sea Level. Read by home secretary.
17. GALLAUDET, E. M. (by invitation of the Academy).—Some Recent Results of the Oral and Aural Teaching of the Deaf under the Combined System. Discussed by Messrs. Coues and Hilgard.
18. GILL, THEO.—On the Ichthyological Peculiarities of the Bassalian Realm. Discussed by Messrs. Verrill and Coues.
19. PAUL, H. M. (by invitation of the Academy).—The Krakatoa Atmospheric Waves and the Question of the Connection between Barometric Pressure and Atmospheric Electricity. Discussed by Mr. Brewer.
20. BILLINGS, JOHN S.—Memorandum on Composite Photographs in Craniology. Read by Mr. Powell.
21. WRIGHT, A. W.—Some Experiments upon the Spectra of Oxygen. Discussed by Mr. Langley.
22. COUES, ELLIOTT.—On the Application of Trinomial Nomenclature to Zoölogy. Discussed by Messrs. Gill and Brewer.
23. CLARKE, F. W. (by invitation of the Academy).—Jade Implements from Alaska.
24. ABBOT, H. L.—Recent Progress in Electrical Fuses.
25. HILGARD, J. E.—Account of Some Recent Pendulum Experiments in Different Parts of the World, made in Connection with the United States Coast and Geodetic Survey.
26. DILLER, J. S. (by invitation of the Academy).—Volcanic Sand that Fell at Unalaska October 20, 1883, and Considerations Concerning its Composition.

ELECTIONS.

The following members were selected for the council for the ensuing year: Messrs. S. F. Baird, W. Gibbs, J. E. Hilgard, M. C. Meigs, S. H. Scudder, and C. A. Young.

NEW MEMBERS.

The following new members were elected: Prof. Edward S. Dana, General C. B. Comstock, U. S. A., Prof. Sidney I. Smith, Capt. C. E. Dutton, U. S. A., and Prof. W. K. Brooks.

TREASURER'S REPORT.

The treasurer presented the following report, which had been examined by the auditing committee, Messrs. Scudder, Abbe, and Pumpelly, and approved:

1. *General account, April* 16, 1883, *to April* 14, 1884.

RECEIPTS.

Cash balance from last year		$230 67
Dues collected from members		471 50
Total assets		702 17

EXPENDITURES.

Stationery and printing	$128 63	
Postage and express	17 37	
Assistant to secretary, April and November	102 78	
Caterer, April meeting	100 00	
Rent of room for library	96 00	
Parchment for diplomas	40 00	
		484 78
Cash balance on hand April 14, 1884		217 39
Dues from members		35 00
District of Columbia 3.65 bond		1,000 00
Total assets		1,252 39

2. *The Bache trust fund.*

RECEIPTS.

Cash balance from last year		$1,414 27
Interest of United States bonds		2,212 72
Interest from other funds		96 00
Total		3,722 99

EXPENDITURES.

Taxes on Missouri land	$5 45	
E. S. Holden, for spectroscopic observations on zodiacal light and auroras	300 00	
		305 45
Balance of income fund, cash		3,417 54
Add District of Columbia loan, 3.65 per cent		4,500 00
Total		7,917 54

The fund itself, of $47,550, remains unchanged since the report in April, 1883.

3. *The Watson fund.*

RECEIPTS.		
Cash balance from last year		$644 75
Interest on United States bonds		279 00
Dividend on stock of Michigan Mutual Life Insurance Company		469 00
		1,392 75
EXPENDITURES.		
Account of solar eclipse of 1883	$100 00	
		100 00
Cash balance on hand April 14, 1884		1,292 75

The investments remain unchanged.

4. *The Henry Draper medal fund.*

RECEIPTS.		
Received from Mrs. Draper, April 20, 1883		$6,000 00
Interest on $5,000 United States bond, 4 per cent		200 00
		6,200 00
EXPENDITURES.		
Expended in purchase of $5,000 United States bond, 4 per cent., April 20, 1883	$6,000 00	
		6,000 00
Cash balance April 14, 1884		200 00

J. H. C. COFFIN,
Treasurer.

The following report of the committee to examine securities held by the Academy was read and approved:

Washington, D. C., April 12, 1884.

The committee, Messrs. Schott and Gilbert, appointed to examine the securities in the hands of the treasurer, report that they have examined said securities, and find they are as follows:

1. *General fund.*

District of Columbia 3.65 per cent	$1,000 00

2. *Bache trust fund.*

United States loan, 4½ per cent	$42,100 00
United States loan, 4 per cent	3,850 00
City of Davenport loan, 6 per cent., coupon	1,000 00
City of Philadelphia loan, 6 per cent	600 00
	47,550 00

Also for deed of 160 acres of Missouri lands, and three gold and one bronze medals.

3. *Income of the Bache fund.*

District of Columbia 3.65 per cent. ($500 of which are coupon)	$4,500 00

4. *Joseph Henry fund.*

An agreement with the Pennsylvania Company for the insurance on lives, and granting annuities, as to the final disposition of the Joseph Henry fund of	$40,000 00

5. *Henry Draper medal fund.*

United States loan, 4 per cent	$5,000 00

These are all, except where noted, registered in the name of the National Academy of Sciences.

Also the deed of Mrs. Henry Draper granting $6,000 for the Henry Draper medal fund.

6. *Watson trust fund.*

United States loan, 4 per cent	$6,200 00
Certificate for 134 shares of capital stock of the Michigan Mutual Life Insurance Company, par	6,700 00
	12,900 00

RECOMMENDATIONS OF THE TRUSTEES OF THE WATSON FUND.

The following recommendations of the trustees of the Watson fund were adopted by the Academy, upon the advice of the council (these recommendations are based on the present cash balance of $1,292.75, and the annual income of present investments, $748):

1. That the invested fund be increased by the addition of $850.25, so that its par value may equal, as near as may be, $13,750.25, the sum received from Professor Watson's estate.

2. That dies, with suitable designs, be prepared for a medal to be awarded from time to time to the person in any country who shall make any astronomical discovery or produce any astronomical work worthy of special reward and contributing to the progress of astronomy, in compliance with the expressed wishes of Professor Watson.

3. That there be set aside annually the sum of $500, or as much thereof as may be necessary and available, to commence work on tables of the small planets discovered by Professor Watson, as also expressly desired by him in his bequest to the Academy, such work to be under the direction of Mr. Newcomb.

DONATION BY MRS. J. LAWRENCE SMITH.

The president announced that the widow of Prof. J. Lawrence Smith, late an honored member of the Academy, intended to place at the disposal of the National Academy of Sciences the sum of $8,000, as a memorial fund to promote the study of meteoric bodies.

Upon recommendation of the council, the Academy adopted the following resolution:

Resolved, That the Academy hears with gratification the announcement that Mrs. J. Lawrence Smith intends to intrust to it a fund to promote the study of meteoric bodies, and hereby signifies its readiness to accept the trust.

The Academy also adopted the recommendation of the council "that the president be authorized to communicate with Mrs. J. Lawrence Smith, and make what arrangements are necessary."

DEATH OF MEMBERS.

The president announced the death of the following members who have died since the last meeting: General A. A. Humphreys, Chief of Engineers, U. S. A., and Prof. Arnold Guyot, of Princeton, N. J.

The following members were appointed to prepare obituary memoirs:

Of General Humphreys: General H. L. Abbot.

Of Professor Guyot: Professor J. D. Dana.

MEMORIAL MEETING.

On the evening of April 17, the Academy met in the lecture hall of the National Museum, for the reading of obituary memoirs, as follows:

Of General G. K. Warren, by General H. L. Abbot.

Of Prof. Stephen Alexander, by Prof. C. A. Young.

Of Prof. J. Lawrence Smith, by Prof. B. Silliman.

Of Dr. John L. Le Conte, by Mr. S. H. Scudder.

Of Prof. Lewis H. Morgan, by Mr. J. W. Powell. (Read by title.)

RESOLUTIONS.

On recommendation of the council, it was resolved that the home secretary have engrossed, and properly signed, the resolution of thanks to Mrs. Draper drawn up at the last stated session, as follows:

Resolved, That the grateful acknowledgments of the National Academy of Sciences are due to Mrs. Draper for the confidence which she has shown in selecting the Academy as the trustee of a fund designed to reward scientific labor, and by so doing to commemorate the services of one who was loved for his virtues, and honored for his eminent success in the branch of science to which he devoted his noble and useful life.

The following resolutions were also adopted:

Resolved, That the National Academy of Sciences authorize the sale of 160 acres of land designated as SE. ¼ of lot 11, township block 34, range 23, in the State of Missouri, held as part of the estate derived from A. D. Bache, for a sum not less than $800; and that the president of the Academy be, and is hereby, authorized and empowered to execute such deed of conveyance to the purchaser, and such other papers as may be required, when he shall regard such sale desirable.

Resolved, That a scientific session be held at Newport, R. I., the second Tuesday (14) in October.

Resolved, That a special stated session be called for Wednesday, October 15, to consider the president's report to Congress, and receive reports of committees on subjects referred to the Academy by the Government.

Resolved, That the proceedings of the Academy that have not already been published, together with unpublished biographical notices, be included in the president's report to Congress.

Resolved, That the treasurer be authorized to reimburse the members of the committee on glucose for expenses incurred in that investigation, and obtain repayment from the Government.

Resolved, That the treasurer be authorized to defray the expenses of the present session on certification by the president.

Resolved, That the assessment for the ensuing year be $5.

CONSTITUTIONAL AMENDMENT.

The Academy adopted the pending amendment to Article IV, section 4, viz: Omit the words "and foreign associates."

REPORTS OF COMMITTEES.

It was reported that the reservation of public lands on and near Mount Whitney, California, for scientific purposes, had been established, and the committee was continued, with the view to securing and utilizing the reservation for the said scientific purposes.

Mr. Pumpelly was appointed to fill the vacancy in the committee on ways and means to provide a fund for the Academy, caused by the death of Mr. J. Lawrence Smith.

In the committee to co-operate with the National Board of Health, Mr. Billings was appointed to take the place of Dr. Engelmann, deceased, and Mr. Brewer to take the place of Mr. J. L. Smith, deceased.

Mr. Powell was appointed a member of the committee on publication.

The committee to represent the Academy before Congress, and the committee on the relation of the Academy to the Government, were, on motion of Mr. Hilgard, united under the latter title, so far as names were not duplicated.

The committee on the Henry Draper medal reported progress.

Mr. Hilgard, on the part of the board of direction of the Bache fund, made a statement of the present condition of the fund, explaining the policy which had formerly guided the board, and the rules adopted by the present board, with the view to having the fund more directly applied to distinct objects, the results of which might be published as "Memoirs of the Bache Fund."

The committee on weights, measures, and coinage, the committee on the triangulation to connect the Atlantic and Pacific coasts, and the committee on publication were continued.

The committee on questions of meteorological science and its application, the committee on the investigation of glucose for the Department of Internal Revenue, and the committee on the total eclipse of May 6, 1883, were discharged.

Dr. Joseph Leidy was, at his request, restored to the roll of members.

INVITATIONS.

During the session, the members of the Academy were invited by Professor Baird, the Fish Commissioner, to call at the central hatching station of the Fish Commission, in the Armory building, to witness the operation of hatching shad.

Members were also invited by the Standard Underground Cable Company, through its vice-president, Mr. R. S. Waring, to examine the underground electric cables laid for the use of the Departments and extending to the National Museum.

The Academy adjourned April 18, 1884.

SCIENTIFIC SESSION.

HELD AT NEWPORT, R. I., OCTOBER 14 TO 17, 1884.

A scientific session, for the reading of papers only, having been called by the council, as announced at the April session, the Academy convened at the court house, Newport, R. I., on October 14, 1884.

The president, Prof. O. C. Marsh, presided.

The following members were present during the session:

Abbot.
Brewer.
Brush.
Coffin.
Comstock.
Cooke.
Cope.
Dana.
Gibbs, W.
Hall, A.
Hilgard, J. E.
Hill, Henry B.
Langley.
Marsh.
Morse.
Packard.
Peirce.
Peters.
Powell.
Pumpelly.
Rogers.
Scudder.
Walker.

The following gentlemen were invited to attend the meetings and to take part in the scientific proceedings: Prof. Edw. B. Tylor, of Oxford, England; Dr. W. Valentiner, director of the observatory at Karlsruhe, Germany; Hon. George Bancroft; Lieut. A. W. Greely, U. S. A.

The following papers were read and discussed:

1. COPE, E. D.—On the Columella Auris of the Pelycosauria. Discussed by the president.
2. PACKARD, A. S.—The Brain of Asellus and the Eyeless Form of Cecidotæa. Discussed by Messrs. Scudder, Packard, and Brewer.
3. GIBBS, WOLCOTT.—On the Theory of Atomic Volumes. Discussed by Mr. Peirce.
4. GIBBS, WOLCOTT.—On the Complex Inorganic Acids.
5. ROGERS, FAIRMAN.—Notice of Muybridge's Experiments on the Motions of Animals by Instantaneous Photography. Discussed by Messrs. Brewer, Cope, Powell, Rogers, and the president.
6. ROGERS, FAIRMAN.—Notice of Grant's Difference Engine. Discussed by Messrs. J. E. Hilgard, A. Hall, Rogers, Peters, Coffin, and Comstock.
7. DANA, E. S.—On the Thinolite of Lake Lahontan. Discussed by the president and Mr. Brewer.
8. PUMPELLY, R.—On the Mesozoic Coals of the Northwest. Discussed by Mr. Powell.
9. PUMPELLY, R.—On the Work of the Northern Transcontinental Survey. Discussed by Mr. Powell.
10. BREWER, W. H.—The Grasses Mechanically Injurious to Live Stock. Discussed by Messrs. Powell, Brewer, Cope, Peters, and the president.
11. PEIRCE, C. S.—On Gravitation Survey.
12. PEIRCE, C. S., and JASTROW, J.—On Minimum Differences of Sensibility. Discussed by Mr. Powell.
13. PETERS, C. H. F.—Researches on Ptolemy's Star Catalogue.
14. POWELL, J. W.—On the Operations of the United States Geological Survey.
15. HALL, A.—The Motion of Hyperion.
16. TYLOR, E. B. (by invitation of the Academy).—Remarks on the Civilization of the Native Peoples of America. Discussed by Messrs. Powell, Cope, J. E. Hilgard, and Brewer.

17. VERRILL, A. E.—Some Results of the Exploration of the Deep Sea beneath the Gulf Stream by the United States Fish Commission Steamer Albatross, during the past Summer. Read by Mr. Pumpelly.
18. ABBOT, H. L.—Recent Progress in Explosives. (Read by title.)
19. PUMPELLY, R.—On an Experimental Composite Photograph of the Members of the Academy. Discussed by Mr. Brewer, the president, and Messrs. Powell, Cope, and Peirce.
20. VALENTINER, W. (by invitation of the Academy).—Report on Meridian Work at Karlsruhe. Discussed by Mr. Peters.
21. PEIRCE, C. S.—On the Algebra of Logic. Discussed by Messrs. Powell and Peirce.
22. LANGLEY, S. P.—On the Temperature of the Lunar Surface.
23. MORSE, EDWARD S.—On the Methods of Eastern Archery.

DEATH OF MEMBERS.

The president announced the death of the following members: Dr. J. J. Woodward, U. S. A., and Dr. R. E. Rogers.

The following members were appointed to prepare obituary memoirs:

Of Dr. Woodward: Dr. J. S. Billings.

Of Dr. Rogers: Mr. F. Rogers.

Since the October meeting, Prof. Benjamin Silliman has died at New Haven, Conn., January 14, 1885.

DEATH OF FOREIGN ASSOCIATES.

During the past year, two foreign associates, J. B. Dumas and Adolphe Würtz, both of Paris, have died.

The scientific session closed October 17, 1884.

SPECIAL SESSION.

HELD AT NEWPORT, R. I., OCTOBER 15, 1884.

A special session of the Academy having been called by the council, in accordance with Article III, section 1, of the constitution, the Academy convened in the court-house at Newport, October 15, 1884, the president, Prof. O. C. Marsh, presiding.

The president was authorized to include in his annual report to Congress, in addition to the detail of the regular proceedings of the sessions, the report of the committee on the organization of the National Surveys and Signal Service, the report of the committee on philosophical and scientific apparatus, reports upon any other business submitted to him during the current year, by the Government of the United States, and the report of the committee on publications of the Academy.

RESOLUTION.

Upon recommendation of the council, the following resolution was unanimously adopted:

Resolved, That the thanks of the Academy be tendered to the sheriff and deputy sheriff of the city of Newport for the use of the court house for the meetings of the Academy, and for their courteous and considerate attention to the convenience of the members.

The special session then adjourned.

Respectfully submitted.

O. C. MARSH,
President of the National Academy of Sciences.

APPENDICES.

APPENDIX A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress asssembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. B. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, St. Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilless, United States Navy, District of Columbia; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania; J. L. Le Conte, United States Army, Pennsylvania; J. Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio: H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherford, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, junior, Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SECTION 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise;

to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institution, and to report the same to Congress.

SECTION 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the Academy shall, whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports, to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

Approved, March 3, 1863.

AN ACT to amend the Act to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act to incorporate the National Academy of Sciences, approved March three, eighteen hundred and sixty-three, be, and the same is hereby, so amended as to remove the limitation of the number of ordinary members of said Academy as provided in said act.

Approved, July 14, 1870.

DEPARTMENT OF STATE, *June* 10, 1882.

True copies.

SEVELLON A. BROWN,
Chief Clerk.

[Public No. 63.]

AN ACT to authorize the National Academy of Sciences to receive and hold trust funds for the promotion of science, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the National Academy of Sciences, incorporated by the act of Congress approved March third, eighteen hundred and sixty three, and its several supplements, be, and the same is hereby, authorized and empowered to receive bequests and donations, and hold the same in trust, to be applied by the said Academy in aid of scientific investigations, and according to the will of the donors.

Approved, June 20, 1884.

DEPARTMENT OF STATE, *June* 24, 1884.

A true copy.

SEVELLON A. BROWN,
Chief Clerk.

APPENDIX B.

CONSTITUTION AND RULES OF THE NATIONAL ACADEMY OF SCIENCES.

As amended and adopted April 17, 1872, and further amended April 20, 1875, April 21, 1881, April 19, 1882, and April 18, 1883.

PREAMBLE.

Empowered by the act of incorporation enacted by Congress and approved by the President of the United States on the 3d day of March, A. D. 1863, and in conformity with the amendment to said act, approved July 14, 1870, the National Academy of Sciences adopt the following amended constitution and rules:

ARTICLE I.—OF MEMBERS.

SECTION 1. The Academy shall consist of members, honorary members, and foreign associates. Members must be citizens of the United States.

SEC. 2. Members who, from age or inability to attend the sessions of the Academy, wish to resign the duties of active membership, may, at their own request, be transferred to the roll of honorary members by a vote of the Academy.

SEC. 3. The Academy may elect fifty foreign associates.

SEC. 4. Honorary members and foreign associates shall have the privilege of attending the meetings, and of reading and communicating papers to the Academy, but shall take no part in its business, shall not be subject to its assessments, and shall be entitled to a copy of the publications of the Academy.

ARTICLE II.—OF THE OFFICERS.

SEC. 1. The officers of the Academy shall be a president, a vice-president, a foreign secretary, a home secretary, and a treasurer, all of whom shall be elected for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner, at the session when such vacancy occurs or at the next stated session thereafter, as the Academy may direct. A vacancy in the office of treasurer or home secretary may, however, be filled by appointment of the president of the Academy until the next stated session of the Academy.

SEC. 2. The officers of the Academy, together with six members to be elected by the Academy at the first stated session in each year, shall constitute a council for the transaction of such business as may be assigned to them by the constitution of the Academy.

SEC. 3. The president of the Academy, or, in case of his absence or inability to act, the vice-president, shall preside at the meetings of the Academy and of the council; shall name all committees except such as are otherwise especially provided for; shall refer investigations required by the Government of the United States to members especially conversant with the subjects, and report thereon to the Academy at its session next ensuing; and, with the council, shall direct the general business of the Academy.

It shall be competent for the president, in special cases, to call in the aid, upon committees, of experts or men of special attainments, not members of the Academy.

SEC. 4. The foreign and home secretaries shall conduct the correspondence proper to their respective departments, advising with the president and council in cases of doubt, and reporting their action to the Academy at one of the stated sessions in each year.

It shall be the duty of the home secretary to give notice to the members, of the place and time of all meetings, of all nominations for membership, and of all proposed amendments to the constitution.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the home secretary.

SEC. 5. The treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the council may require. He shall collect all dues from members, and keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the April session. He shall be the custodian of the corporate seal of the Academy.

ARTICLE III.—OF THE MEETINGS.

SEC. 1. The Academy shall hold one stated session in each year, in the city of Washington, on the third Tuesday in April, and another may be held at such place and time as the council shall determine.

Special sessions of the Academy may be called by order of eight members of the council, at such place and time as may be designated in the call.

Scientific sessions of the Academy may be held at times and places to be designated by a majority of the council.

SEC. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SEC. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business, closed.

SEC. 4. The stated meetings of the council shall be held during the stated or special sessions of the Academy. Special meetings may be convened at the call of the president and two members of the council, or of four members of the council.

SEC. 5. No member who has not paid his dues shall take part in the business of the Academy.

ARTICLE IV—OF ELECTIONS AND RESIGNATIONS.

SEC. 1. All elections shall be by ballot, and each election shall be held separately, unless otherwise ordered by this constitution.

SEC. 2. The time for holding an election for officers shall be fixed by the Academy at least one day before the election is held.

SEC. 3. The six additional members of the council shall be elected on any day after the first of the first stated session in each year, by each voter inscribing six names on his ballot, and those six who have received more votes than any others shall be declared elected. If two or more names have received the lowest number of votes that would elect, additional balloting shall be had for as many members as remain each time to be elected until the number is full.

The term of the members so elected shall commence at the close of the session at which they are elected, and continue until the close of the first stated session in the next year.

SEC. 4. Nominations of members may be made in writing, signed by any five members of the Academy, at any stated session, to be voted on at the next stated session held in Washington; and each nomination shall, at the time of election, be accompanied by a written list of the original works of the nominee.

SEC. 5. Elections for membership shall be held in the following manner: Each member may inscribe on a ballot not more than five names of nominees selected from the list. Absent members may send such ballots to the home secretary. From the seven names receiving the highest number of votes in this preference ballot, the members present may proceed to elect new members in the following manner: At each ballot each member present may vote for not exceeding three persons, and the person receiving the highest number of votes shall be declared elected: *Provided*, That he received two-thirds of the votes cast, and that his name appear on not less than twenty ballots: *And provided further*, That the number of members of the Academy be not already one hundred or over, in which case, to be declared to be elected, he must receive four-fifths of the votes cast, and his name must appear on at least twenty-five ballots.

Should several candidates have the same minimum number of votes on the preference list, the requisite number for completing the list shall be selected from them by a two-thirds vote of the members present.

Election of members shall be held only at the regular stated session of each year held in Washington, and not more than five members shall be elected at that session.

Before, and during elections, a discussion of the merits of nominees will be in order.

The election of members may be suspended at any time by a majority vote of the members present.

SEC. 6. Every member-elect shall accept his membership, personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SEC. 7. Foreign associates may be nominated by a committee of five members to be appointed for that purpose by the president, and elected at any stated session by a two-thirds vote of the members present. The election shall be had by each member indicating on a ballot those names for which he votes, and those nominees whose names appear on two-thirds of the ballots shall be declared elected.

SEC. 8. A diploma, with the corporate seal of the Academy, and the signatures of the officers, shall be sent by the appropriate secretary to each member on his acceptance of his membership, and to foreign associates on their election.

SEC. 9. Resignations shall be addressed to the president, and acted on by the Academy.

ARTICLE V.—OF SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

SEC. 1. Communications on scientific subjects shall be read at scientific meetings of the Academy, and papers by any member may be read by the author, or by any other member, notice of the same having been previously given to the secretary.

SEC. 2. Any member of the Academy may read a paper from a person who is not a member, and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

Persons who are not members may read papers on invitation of the president, with the advice of the council.

SEC. 3. The Academy may provide for the publication, under the direction of the council, of proceedings, memoirs, and reports.

SEC. 4. Propositions for investigations or reports by the Academy shall be submitted to the council for approval, except those requested by the Government of the United States, which shall be acted on by the president, who will in such cases report their results to the Government as soon as obtained, and to the Academy at its next following stated session.

SEC. 5. The advice of the Academy shall be, at all times, at the disposition of the Government upon any matter of science or art within its scope.

SEC. 6. An annual report to be presented to Congress shall be prepared by the president, and, before its presentation, submitted by him, first to the council, and afterwards to the Academy, at one of the stated sessions.

SEC. 7. Medals and prizes may be established, and the means of bestowing them accepted by the Academy, upon the recommendation of the council, by whom all the necessary arrangements for their establishment and award shall be made.

Bequests and trusts having for their object the advancement of science may also be accepted, and administered by the Academy.

ARTICLE VI.—OF THE PROPERTY OF THE ACADEMY.

SEC. 1. All investments shall be made by the treasurer, in the corporate name of the Academy, in stocks of the United States.

SEC. 2. No contract shall be binding upon the Academy which has not been first approved by the council.

SEC. 3. The assessments required for the support of the Academy shall be fixed by the Academy, on the recommendation of the council.

ARTICLE VII.—OF ADDITIONS AND AMENDMENTS.

Additions and amendments to the constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change must be given at a stated session, and shall be referred to the council, which may amend the proposition, and shall report thereon to the Academy at the same session. Its report shall be considered by the Academy in committee of the whole for amendment.

The proposition as amended, if adopted in committee of the whole, shall be voted on at the next stated session, and if it receive two-thirds of the votes cast it shall be declared adopted.

Absent members may send their votes on pending changes in the constitution to the home secretary, in writing, and such votes shall be counted as if the member were present.

RULES.

I. In the absence of any officer, a member shall be chosen to perform his duties temporarily, by a plurality of *viva voce* votes, upon open nominations.

II. The accounts of the treasurer shall be referred to an auditing committee of three members, to be appointed by the president at the meeting at which the accounts are presented, which committee shall report before the close of that session, and shall then be discharged.

The bonds, securities, and other property owned or held in trust by the Academy shall be inspected and verified by a committee to be annually appointed by the president. The report of this committee shall be presented to the Academy at its first stated session in each year, and referred with the accounts to the auditing committee.

III. A committee of arrangements consisting of five members shall be appointed by the president for each stated session of the Academy. This committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, &c.; and toarrange the order of reading, and, in general, to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be as follows:

1. Chair taken by the president, or, in his absence, by the vice-president.
2. Roll of members called by home secretary.
3. Minutes of the preceding meeting read and approved.
4. Stated business.
5. Reports of president, secretaries, treasurer, and committees.
6. Business from council.
7. Other business.
8. On the last day of the session, the rough minutes of that day's proceedings are to be read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless suspended by unanimous consent.

VI. Unless otherwise ordered by the Academy, the scientific meetings shall be convened at noon.

VII. The death of members shall be announced by the president on the last day of any session, when a member shall be selected by the president to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member may be selected by the president in place of the first, and so on until the duty is performed.

VIII. All discussions as to the claims and qualifications of nominees at meetings of the Academy will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the Academy at the time of the discussion.

IX. The secretaries will receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy.

X. Memoirs shall date in the records of the Academy from the date of their presentation to the Academy, and the order of their presentation shall be that in which they were registered, unless changed by consent of the author.

XI. Papers from persons not members, read before the Academy, and intended for publication, shall be referred, at the meeting at which they are read, to a committee of members competent to judge whether the paper is worthy of publication. Such committee shall report to the Academy as early as practicable, and not later than the next stated session.

XII. An annual of the Academy shall be prepared and published by the secretaries.

XIII. The printing of the Academy shall be under the charge of a committee of publication, to consist of the home secretary and four other members to be named by the president, with the advice and consent of the council.

XIV. The annual report of the Academy may be accompanied by a memorial to Congress in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XV. The proper secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XVI. The books, apparatus, archives, and other collections of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles so deposited shall be kept by the home secretary, who is authorized to employ a clerk to take charge of them.

XVII. A stamp corresponding to the corporate seal of the Academy shall be kept by the secretaries, who shall be responsible for the due marking of all books, and other objects to which it is applicable.

Labels or other proper marks of similar device shall be placed upon objects not admitting of the stamp.

XVIII. On the first day of each stated session, immediately after calling the roll of members, a recording secretary shall be elected by a plurality of members present to assist the home secretary in keeping the records of the session.

XIX. It shall be the duty of the committee of arrangements to fix the length of time to be devoted to reading of all papers submitted, and to limit the time to be occupied in their discussion.

XX. Ballots for election of members may be sent by sealing them up in a blank envelope, and inclosing this in another, across the back of which is written the name of the sender, and which is addressed to the home secretary. Such envelopes will be opened only by the tellers.

XXI. Any rule of the Academy may be amended, suspended, or repealed on the written motion of any two members, signed by them, and presented at a stated session of the Academy, provided the same shall be approved by a majority of the members present.

XXII. Nominations for membership should state the full name, residence, the official position, and the special scientific studies of the candidate. A form of nomination shall be prepared by the home secretary.

By a resolution adopted January 12, 1864, the president is, *ex officio*, a member of all Government committees of the Academy.

APPENDIX C.

ORGANIZANION OF THE ACADEMY, 1884.

	Expiration of term.
Marsh, O. C., *President*	April, 1889
Newcomb, S., *Vice-President*	April, 1889
Agassiz, Alexander, *Foreign Secretary*	April, 1886
Hall, A., *Home Secretary*	April, 1889
Coffin, J. H. C., *Treasurer*	April, 1887

ADDITIONAL MEMBERS OF COUNCIL, 1884-'85.

Baird, S. F.
Gibbs, W.
Hilgard, J. E.
Meigs, M. C.
Scudder, S. H.
Young, C. A.

COMMITTEES OF THE ACADEMY.

On Ways and Means to Provide a Fund for the Academy.

Rogers, Fairman, *Chairman.*
Chandler, C. F.
Marsh, O. C.
Agassiz, Alexander.
Pumpelly, R.

On Weights, Measures, and Coinage.

Barnard, F. A. P., *Chairman.*
Gibbs, Wolcott.
Hilgard, J. E.
Meigs, M. C.
Newcomb, S.
Newton, H. A.
Peirce, C. S.
Trowbridge, W. P.

On the Election of Foreign Associates.

Agassiz, Alexander, *Chairman.*
Dana, J. D.
Gibbs, W.
Hall, A.
Newcomb, S.

On Reserving Public Lands on and near Mount Whitney, California, for Scientific Purposes.

Langley, S. P., *Chairman.*
Brewer, W. H.
Powell, J. W.

To Report on the Triangulation to Connect the Atlantic and Pacific Coasts.

Abbot, H. L., *Chairman.*
Barnard, F. A. P.
Meigs, M. C.
Newberry, J. S.
Newcomb, S.
Newton, H. A.
Powell, J. W.

COMMITTEES OF THE ACADEMY—Continued.

To co-operate with the National Board of Health.

MITCHELL, S. WEIR, Philadelphia, Pa., *Chairman.*
BILLINGS, J. S., Washington, D. C.
BREWER, W. H., New Haven, Conn.
WOODWARD, J. J., Washington, D. C.
WALKER, F. A., Boston, Mass.
BARKER, GEORGE F., Philadelphia, Pa.
CHANDLER, CHARLES F., New York City.
GIBBS, WOLCOTT, Cambridge, Mass.

On Publication.

THE HOME SECRETARY.
BAIRD, S. F.
COFFIN, J. H. C.
NEWCOMB, S.
POWELL, J. W.

On Publications of the Academy.

GILL, T.

On the Relation of the Academy to the Government.

THE PRESIDENT.
VICE-PRESIDENT.
SECRETARIES.
BAIRD, S. F.
COFFIN, J. H. C.
HILGARD, J. E.
MEIGS, M. C.
POWELL, J. W.

On the Organization of the National Surveys and Signal Service.

MEIGS, M. C., *Chairman.*
BREWER, WILLIAM H.
COMSTOCK, C. B.
LANGLEY, S. P.
NEWCOMB, S.
PICKERING, E. P.
TROWBRIDGE, W. P.
WALKER, F. A.
YOUNG, C. A.

On Customs Duty on Philosophical and Scientific [illegible]

BRUSH, G. J., *Chairman.*
GIBBS, WOLCOTT.
SCUDDER, S. H.
NEWCOMB, S.
BARKER, G. F.

TRUST FUNDS.

Board of Direction of the Bache Fund.

DANA, J. D.
HILGARD, J. E.
GIBBS, W.

Board of Trustees of the Watson Fund.

HILGARD, J. E.
NEWCOMB, S.
COFFIN, J. H. C.

On the Henry Draper Medal.

BARKER, G. F., *Chairman.*
GIBBS, W.
NEWCOMB, S.
WRIGHT, A. W.
YOUNG, C. A.

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, JANUARY 20, 1885.

		Date of election.
Abbe, Cleveland	*Washington, D. C.*	1879
Abbot, Henry L., U. S. A	*Whitestone, Long Island, N. Y.*	1872
Agassiz, Alexander	*Cambridge, Mass.*	1866
Allen, J. Asaph	*Cambridge, Mass.*	1876
Baird, Spencer F	*Washington, D. C.*	1864
Barker, George F	*Philadelphia, Pa.*	1876
Barnard, Frederick A. P	*New York City.*	——
Bartlett, William H. C	75 *Locust Hill Ave., Yonkers, N. Y.*	——
Bell, A. Graham	*Washington, D. C.*	1883
Billings, John S., U. S. A	*Washington, D. C.*	1883
Brewer, William H	*New Haven, Conn.*	1880
Brooks, W. K	*Johns Hopkins University, Baltimore, Md.*	1884
Brown-Sequard, Charles E	*Paris, France.*	1868
Brush, George J	*New Haven, Conn.*	1868
Chandler, Charles F	*New York City.*	1874
Coffin, John H. C., U. S. N	*Washington, D. C.*	——
Comstock, Cyrus B., U. S. A	*Army Building, New York City.*	1884
Cooke, Josiah P	*Cambridge, Mass.*	1872
Cope, Edward D	2100 *Pine St., Philadelphia, Pa.*	1872
Coues, Elliott	*Washington, D. C.*	1877
Crafts, James M	*Boston, Mass.*	1872
Dalton, J. C	43 *W. Forty-eighth St., New York City.*	1864
Dana, Edward S	*New Haven, Conn.*	1884
Dana, James D	*New Haven, Conn.*	——
Davidson, George	*San Francisco, Cal.*	1874
Dutton, Clarence E., U. S. A	*Washington, D. C.*	1884
Eads, James B	*Saint Louis, Mo.*	1872
Farlow, W. G	*Cambridge, Mass.*	1879
Ferrel, William	*Washington, D. C.*	1868
Genth, Frederick A	*West Philadelphia, Pa.*	1872
Gibbs, Josiah Willard	*New Haven, Conn.*	1879
Gibbs, Wolcott	*Cambridge, Mass.*	——
Gilbert, Grove K	*Washington, D. C.*	1883
Gill, Theodore N	*Washington, D. C.*	1873
Gould, Benjamin A	*Cordoba, Argentine Republic, S. A.*	——
Hall, Asaph, U. S. N	*Washington, D. C.*	1875
Hall, James	*Albany, N. Y.*	——
Hayden, F. V	1803 *Arch St., Philadelphia, Pa.*	1873
Hilgard, Eugene W	*Oakland, Cal.*	1872
Hilgard, Julius E	*Washington, D. C.*	——
Hill, George W	*Washington, D. C.*	1874
Hill, Henry B	*Cambridge, Mass.*	1883
Hunt, T. Sterry	*Montreal, Canada.*	1873
Hyatt, Alpheus	*Soc. of Nat. History, Boston, Mass.*	1875
Jackson, Charles L	*Cambridge, Mass.*	1883
Johnson, Samuel W	*New Haven, Conn.*	1866
King, Clarence	62 *Cedar St., New York City.*	1876
Langley, Samuel P	*Observatory, Allegheny, Pa.*	1876
Leidy, Joseph	*Philadelphia, Pa.*	1884
Lesley, J. Peter	1008 *Clinton St., Philadelphia, Pa.*	——
Le Conte, John	*Berkeley, Cal.*	1878

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES—Continued.

		Date of election.
Le Conte, Joseph	*Berkeley, Cal.*	1875
Lesquereux, Leo	302 *Fourth St., Columbus, Ohio.*	1864
Loomis, Elias	*New Haven, Conn.*	1873
Lovering, Joseph	*Cambridge, Mass.*	1873
Lyman, Theodore	*Brookline, Mass.*	1872
Marsh, O. C	*New Haven, Conn.*	1874
Mayer, Alfred M	*Hoboken, N. J.*	1872
Meigs, Montgomery C., U. S. A	*Washington, D. C.*	1865
Mitchell, S. Weir	1332 *Walnut St., Philadelphia, Pa.*	1865
Morse, Edward S	*Salem, Mass.*	1876
Morton, Henry	*Hoboken, N. J.*	1874
Newberry, J. S	*New York City.*	—
Newcomb, Simon, U. S. N	*Washington, D. C.*	1869
Newton, H. A	*New Haven, Conn.*	—
Newton, John, U. S. A	*Army Building, New York City.*	1876
Oliver, James E	*Ithaca, N. Y.*	1872
Packard, A. S	*Providence, R. I.*	1872
Peirce, Charles S	*U. S. C. Survey, Washington, D. C.*	1877
Peters, C. H. F	*Clinton, N. Y.*	1876
Pickering, Edward C	*Cambridge, Mass.*	1873
Powell, John W	*Washington, D. C.*	1880
Pumpelly, Raphael	*Gibbs Ave., Newport, R. I.*	1872
Remsen, Ira	*Johns Hopkins University, Baltimore, Md.*	1882
Rogers, Fairman	202 *W. Rittenhouse Sq., Philadelphia, Pa.*	—
Rood, Ogden N	*New York City.*	1865
Rowland, Henry A	*Johns Hopkins University, Baltimore, Md.*	1881
Rutherfurd, Lewis M	175 *Second Ave., New York City.*	—
Schott, Charles A	*Washington, D.C.*	1872
Scudder, Samuel H	*Cambridge, Mass.*	1877
Sellers, William	1600 *Hamilton St., Philadelphia, Pa.*	1873
Smith, Sidney I	*New Haven, Conn.*	1884
Trowbridge, John	*Cambridge, Mass.*	1878
Trowbridge, William P	*New York City.*	1872
Trumbull, J. H	*Hartford, Conn.*	1872
Tuckerman, Edward	*Amherst, Mass.*	1868
Verrill, A. E	*New Haven, Conn.*	1872
Walker, Francis A	*Boston, Mass.*	1878
Wood, Horatio C	1925 *Chestnut St., Philadelphia, Pa.*	1879
Worthen, A. H	*Springfield, Ill.*	1872
Wright, Arthur W	*New Haven, Conn.*	1881
Young, Charles A	*Princeton, N. J.*	1872

HONORARY MEMBERS.

Gray, Asa	*Cambridge, Mass.*
Longstreth, Miers F	*Derby, Pa.*

DECEASED MEMBERS.

	Date of death.
* Agassiz, Louis	Dec. 14, 1873
* Alexander, J. H	Mar. 2, 1867
* Alexander, Stephen	June 25, 1883
* Bache, Alexander Dallas	Feb. 14, 1867
Barnard, J. G	May 14, 1882
* Caswell, Alexis	Jan. 8, 1877
* Chauvenet, William	Dec. 13, 1870
* Clark, Henry James	July 1, 1873
* Coffin, James H	Jan. 6, 1873
Davis, Charles H	Feb. 18, 1877
Draper, Henry	Nov. 20, 1882
Draper, John W	Jan. 4, 1882
Engelmann, George	Feb. 11, 1884
* Frazer, John Fries	Oct. 14, 1872
* Gabb, William M	May 30, 1878
* Gilliss, James Melville	Feb. 9, 1865
* Gould, Augustus A	Sept. 15, 1866
Guyot, Arnold	Feb. 8, 1884
* Henry, Joseph	May 13, 1878
* Hadley, James	Aug. 1, 1864
* Hitchcock, Edward	Feb. 27, 1864
* Holbrook, J. E	Sept. 8, 1871
* Hubbard, J. S	Aug. 16, 1863
* Humphreys, A. A	Nov. 28, 1883
* Haldeman, S. S	Sept. 10, 1880
* Kirtland, Jared P	Dec. 10, 1877
* Lane, J. Homer	—— —, 1880
* Le Conte, John L	Nov. 15, 1883
* Mahan, D. H	Sept. 16, 1871
Marsh, G. P	July 23, 1882
* Meek, F. B	Dec. 21, 1877
* Morgan, Lewis H	Dec. 14, 1881
Norton, William A	Sept. 21, 1883
* Pourtales, L. F	July 17, 1880
Rodgers, John	May 5, 1882
Rogers, Robert E	Sept. 6, 1884
Rogers, William B	May 30, 1882
* Saxton, Joseph	Oct. 26, 1873
* Silliman, Benj., Sr	Nov. 24, 1864
Silliman, Benj., Jr	Jan. 14, 1885
* Smith, J. Lawrence	Oct. 12, 1883
Stimpson, William	May 26, 1873
* Strong, Theodore	Feb. 1, 1869
* Sullivant, W. S	Apr. 30, 1873
* Torrey, John	Mar. 10, 1873
* Totten, J. G	Apr. 22, 1864
* Warren, G. K	Aug. 8, 1882
Watson, James C	Nov. 23, 1880
* Winlock, Joseph	Jan. 11, 1875
* Woodward, J. J., U. S. A	Aug. 18, 1884
* Wyman, Jeffries	Sept. 4, 1874

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* Biographical notices have been presented of those designated by a *.

FOREIGN ASSOCIATES.

BUNSEN, ROBERT W	*Heidelberg.*
MILNE-EDWARDS, HENRY	*Paris.*
AIRY, SIR GEORGE B	*Greenwich.*
OWEN, RICHARD	*London.*
BURMEISTER, C. H. C	*Buenos Aires.*
STRUVE, OTTO VON	*Pulkova.*
ADAMS, J. C	*Cambridge.*
CAYLEY, ARTHUR	*Cambridge.*
CLAUSIUS, RUDOLPH	*Bonn.*
HELMHOLTZ, BARON H. VON	*Berlin.*
KIRCHOFF, G. R	*Berlin.*
PASTEUR, LOUIS	*Paris.*
STOKES, G. G	*Cambridge.*
SYLVESTER, J. J	*Oxford.*
HOOKER, SIR J. D	*Kew.*
THOMSON, SIR WILLIAM	*Glasgow.*
AUWERS, ARTHUR	*Berlin.*
BERTRAND, J. L. F	*Paris.*
HUXLEY, T. H	*London.*
VIRCHOW, RUDOLPH VON	*Berlin.*
BERTHELOT, M. P. E	*Paris.*
BOUSSINGAULT, J. B. J. D	*Paris.*
CHEVREUL, M. E	*Paris.*
DE CANDOLLE, ALPHONSE	*Geneva.*
KÖLLIKER, ALBERT VON	*Würzburg.*
OPPOLZER, THEODORE VON	*Vienna.*
RICHTHOFEN, F. VON	*Berlin.*

DECEASED FOREIGN ASSOCIATES.

SIR WILLIAM ROWAN HAMILTON.
KARL ERNST VON BAER.
MICHAEL FARADAY.
L. ELIE DE BEAUMONT.
SIR DAVID BREWSTER.
G. A. A. PLANA.
F. W. A. ARGELANDER.
FRIEDRICH WÖHLER.
J. B. DUMAS.
MICHEL CHASLES.
SIR RODERICK I. MURCHISON.
VICTOR REGNAULT.
H. W. DOVE.
C. A. F. PETERS.
JUSTUS VON LIEBIG.
ALEXANDER BRAUN.
JOACHIM BARRANDE.
ADOLPHE WÜRTZ.

APPENDIX D.

REPORT ON THE NATIONAL SURVEYS AND SIGNAL SERVICE.

[CORRESPONDENCE.]

THE NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., October 16, 1884.

SIR: I have the honor to transmit herewith the report of the committee of the National Academy of Sciences on the organization of the National Surveys and Signal Service, made in accordance with the request of the Congressional commission contained in your communication dated July 9, 1884. I send with the report—

1. A letter from the Chief Officer of the Signal Service,
2. A letter from the Director of the Geological Survey.
3. A letter from the Superintendent of the Coast and Geodetic Survey.
4. A letter from the Chief Hydrographic Officer of the Navy.

Also various other documents referred to in the report.

Very respectfully yours,

O. C. MARSH,
President of the National Academy of Sciences.

Hon. THEODORE LYMAN.

REPORT.

To the PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES:

SIR: The committee appointed by you to report upon certain organizations and works of the Government has the honor to submit the following report.

The authority under which the committee acted is shown in the following documents:

YALE COLLEGE,
New Haven, Conn., August 2, 1884.

DEAR SIR: I inclose herewith a communication from the Joint Commission appointed by Congress to consider the present organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with a view to secure greater efficiency and economy of administration of the public service in said Bureaus, and the accompanying request for the appointment of a committee of the National Academy of Sciences to aid this Commission.

In response to this request, I have appointed the following committee from the National Academy of Sciences:

General M. C. Meigs, U. S. A. (chairman), Washington, D. C.
Prof. William H. Brewer, Yale College, New Haven, Conn.
Col. Cyrus Comstock, United States Corps of Engineers, New York City.
Prof. S. P. Langley, Observatory, Alleghany, Pa.
Prof. Simon Newcomb, Nautical Almanac Office, Washington, D. C.
Prof. E. C. Pickering, Harvard Observatory, Cambridge, Mass.
Prof. W. P. Trowbridge, Columbia College, New York City.
President Francis A. Walker, Institute of Technology, Boston, Mass.
Prof. C. A. Young, Princeton College, Princeton, N. J.

The members of this committee have all accepted their appointments, and I now place the whole matter in your charge, in full confidence that you appreciate the importance, both to science and to the Academy, of the work before you.

Very truly yours,

O. C. MARSH,
President of the National Academy of Sciences.

General M. C. MEIGS, U. S. A.

NOTE.—Professor Newcomb and General Comstock subsequently withdrew from the committee at the request of their superior officers, the Secretary of the Navy and the Secretary of War.

HOUSE OF REPRESENTATIVES,
Washington, D. C., July 9, 1884.

Prof. O. C. MARSH,
President of the National Academy of Sciences:

DEAR SIR: I beg leave to call your attention to the following clause in the sundry civil bill which has just been passed by Congress:

"That a Joint Commission, consisting of three Senators, appointed by the President of the Senate, and three members of the House, to be appointed by the Speaker of the House of Representatives, shall consider the present organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with the view to secure greater efficiency and economy of administration of the public service in said Bureaus; and said Joint Commission shall report to their respective houses on the third Monday in December, 1884, their conclusions, by bill or report."

The members appointed under this act are:

Senate.—Hon. William B. Allison (chairman), Hon. Eugene Hale, Hon. George H. Pendleton.

House.—Hon. Robert Lowry, Hon. H. A. Herbert, Hon. Theodore Lyman.

You will observe that there is involved nothing less than an investigation of four important branches of our Government, all of them scientific in their character. With the exception of the Coast Survey, these branches have taken on especial importance only within the last few years. They have grown rapidly, and have reached a position where they, in some respects, impinge one on another in such a way as to threaten, in certain cases, a duplication of work, and perhaps some waste and confusion.

The members of the Joint Commission feel that, in a matter of such importance, they should have the counsel of all men who have special knowledge of the questions involved. They are of the opinion that, in addition to the information which the Departments can furnish, they should have the advice of a committee of the National Academy of Sciences.

You are therefore requested to appoint, at your early convenience, such a committee, whose duty it shall be to report on the subject matter of the clause in the *sundry civil bill already* quoted.

As a guide in this investigation, the following points are suggested for your consideration:

First. What is the organization of the government surveys, and of the signal service, in the chief countries of Europe, and could any part of this organization be advantageously adopted in this country?

Secondly. In what way can the scientific branches above referred to be best co-ordinated?

Thirdly. What changes in, or additions to, these branches are desirable?

Except as illustrating the general subject, it will not be necessary for the committee to enter in detail into the expenses of these branches, or the number of their employés.

As the Joint Commission are directed to report on the third Monday in December, the report of the Committee of the National Academy should, if possible, be ready by the first day of next October. The report may be forwarded to me in Brookline, Mass.

By order of the Commission.

Very respectfully,

THEODORE LYMAN, M. C.

These papers show a desire on the part of Congress that the work of these four organizations should be more thoroughly co-ordinated than it is now, and it is from this point of view that your committee has considered the subject. In order to obtain definite information respecting the present operations of the four organizations above mentioned, letters were addressed to the heads of the Executive Departments to which they are attached, respectively, through the proper official channels, requesting from each a statement of their operations. Subsequently the requests were extended to include any views which their chiefs might see fit to present upon the subject to be inquired into. This correspondence is given in the Appendix to this report.

ORGANIZATION IN FOREIGN COUNTRIES.

The land maps of European countries are as a rule made under the direction of the war departments of those countries, and under the direction of officers of the army specially detailed for that duty, with the aid of experts in the business, and in the arts necessary to the surveys and to the production of the charts, who are employed from civil life, and also of enlisted soldiers and non-commissioned officers detailed from the army.

For details on this subject, the committee refers to the printed notes on European surveys compiled and published in 1876, under the direction of one of its members, General C. B. Comstock, United States Engineers, as the most complete compendium on this subject known to them; also to some manuscript notes prepared by the committee from reports and publications of later date.

The hydrographic surveys of the coasts of Europe appear in every country to be the work of the naval establishment.

On the coasts of the United Kingdom, the hydrography has been completed, and now two parties in surveying vessels of the navy are constantly employed in re-sounding and examining channels, harbors, and shoals, in order to correct the existing Admiralty charts. All this is done under direction of the Admiralty.

While the organization of the land and of the hydrographic surveys in Europe is very perfect, your committee does not find that it offers anything to improve that of the United States, except perhaps in showing the economy in time and money of greater use of photography and of zincography in the reduction and production of maps and charts. In Great Britain now, the twenty-five inch to the mile map is published even earlier than those on smaller scales, all of which are reductions from the original manuscript maps surveyed and plotted on the twenty-five-inch or six-inch scale.

Early and cheap publication of results of operations in the field, if they retain the accuracy of the original maps, are of great industrial and economic importance. The English maps of the ordnance survey are published and placed on sale as soon as printed, and at very moderate prices. For details, your committee refers to the manuscript notes on the ordnance survey herewith.

Your committee would call attention in this connection to the report made by the National Academy of Sciences to Congress in December, 1878, in which, the advantages of a consolidation of the then existing surveys were pointed out. In that report, it was recommended that surveys should be two in number; the coast and interior survey, to be concerned with the triangulation and mapping of the country and its topography, and a geological survey, to undertake geological and economical investigations. It would be a part of the duty of the first survey to supply the maps for the use of the geological survey; and, in order to secure the co-ordination and harmonious co-operation of the two surveys, it was recommended that the coast and interior survey be transferred to the Interior Department.

Congress adopted so much of this recommendation as related to the formation of a single Geological Survey, but did not provide for the proposed transfer of the Coast Survey, nor make any other provision for the topographic work necessary for the Geological Survey. The result has been that these two Surveys do not co-operate as they should. The Chief of the Geological Survey has also found it necessary to employ large corps of men in trigonometric measurements.

Your committee does not feel entire confidence that the union of these two surveys under either one of the Executive Departments, would, without other measures, necessarily lead to that unity of work which is desirable. It therefore recommends certain further legislative measures, the occasion for which will be made clear by a review of the work done by these several organizations; but its members are entirely clear in the opinion that some one of the Executive Departments should control both. It is for Congress to determine which Department shall exercise this necessary authority and control.

The Coast Survey was originally organized for the purpose of constructing maps and charts of the coast and harbors for the benefit of commerce and navigation. Conflicting opinions respecting the proper management of the Survey led to the formation in 1843, of a board of officers with the duty of reorganizing the Survey. This board submitted a plan, which was enacted by Congress into law, upon and under which law, the Survey has hitherto been executed.

This plan provided for the co-operation of military officers, naval officers, and civilians in the various parts of the work. Under it, the work of the Coast Survey has been continued to the present time.

In recent times, a great extension of the field of operations of the Survey has been made, apparently looking to a triangulation covering the entire territory of the United States. The maps published annually with the report of the Survey enable us to know the geodetic work it has executed. It appears from the maps accompanying the report of 1882, that on June 30th of that year, a chain of triangles had been extended throughout the entire length of the Atlantic and Gulf coasts, and throughout about half the Pacific coast. Besides these coast lines, extensive regions in the interior are seen to be triangulated. In the northeast, the triangulation covers the greater part of the States of New Hampshire, Vermont, and Massachusetts, about half of Connecticut, and it also includes a considerable part of the State of New York.

The reconnaissance has extended westward from the New Jersey coast so as to include the greater part of the State of New Jersey, and a long strip in Pennsylvania. From Pennsylvania, the extended line of primary triangulation follows the Allegheny Mountains into Northern Alabama, and is now being continued across the country to Memphis.

A triangulation of the Mississippi River was extended from its mouth nearly to Memphis, where it would meet the last described chain of triangles. The chain connecting the Atlantic and Pacific coasts has been completed nearly across the State of Nevada, and the reconnaissance includes nearly half of Utah Territory. The line is also surveyed at various points in Colorado, Kansas, Missouri, and Illinois. Besides all this, isolated regions in Wisconsin, Indiana, Illinois, Ohio, Kentucky, and Tennessee have been reconnoitered by the Coast and Geodetic Survey in a way indicative of a plan designed ultimately to cover the entire territory.

As its appropriations for some years past have made provision for the collection of data for a general map of the United States, we may fairly regard the Coast and Geodetic Survey as having undertaken a trigonometric survey of the whole United States. (See the communication from the Superintendent of this Survey herewith.)

From the statement of the Director of the Geological Survey, appended hereto, we learn that under authority of the annual appropriation bills to prepare a geological map of the United States, that officer has parties engaged in the trigonometric survey of the entire country to be sufficiently accurate for cartographic purposes.

It appears, therefore, that two distinct and independent trigonometric surveys of the United States, under two different Departments of the Government, are now in process of execution.

The meteorological work of the Signal Service is divisible into two distinct branches.

The first, and by far the larger portion of the work is the collection of weather reports from stations in different parts of the Union, which are utilized in predicting the probable weather during the twenty-four hours succeeding. Connected with this work is the publication of weather maps, showing at a glance the state of the weather over the entire country at certain moments of absolute time. At the school at Fort Myer, observers and operators are trained for this service. A very important part of its work is the display of signals and warnings of approaching storms, frosts, and floods.

The other branch of the meteorological service appears in scientific discussions and investigations, having for their object to advance the science of meteorology. These researches are published under the title, "Professional Papers of the Signal Service," which papers consist of memoirs separately paged and numbered in the order of their issue.

Your committee is not informed of the separate expenses of these two divisions of the Signal Service, but has no doubt that the expense of the second branch is but a small fraction of that of the first.

The Signal Service also performs a military duty, providing the material, and instructing soldiers and officers to communicate between separate bodies of troops by a system of day and night signals; and it also operates and repairs, and, when necessary, constructs telegraph lines for military purposes. The appropriation for these military works and services for the current year is $5,000.

In the opinion of the committee, it is desirable that the meteorological work of the Weather Bureau should be under the general control of the commission proposed later in this paper.

The Hydrographic Office of the Navy Department may be considered to date from the year 1848, when the depot for charts and instruments for the Navy, authorized by an act approved in 1842, was established. Under this act, an observatory was established, and was engaged in the double work of making astronomical observations, correcting chronometers, and of supplying charts to the Navy, the establishment being officially styled the United States Naval Observatory and Hydrographic Office. In 1866, Congress authorized the establishment of a separate hydrographic office, to be attached to the Bureau of Navigation in the Navy Department, for the purpose of supplying nautical publications and information, not only to vessels of the United States, but to navigators generally.

Before that time, the functions of the office had been confined to the purchase and distribution of foreign charts. Under the new organization, a drawing and engraving division was established, which constructs charts of foreign coasts and seas for distribution to vessels of the Navy, and for sale, at the cost of printing and paper, to navigators generally.

The officer now in charge of the Hydrographic Office appeared before your committee in person, and gave it a very clear account of the work his office is actually doing. A memoir by this officer, transmitted to the committee by the honorable the Secretary of the Navy, accompanies this report.

Besides the hydrographic work of the Coast Survey, which is conducted, and has always been conducted under existing laws, under the direction of the Superintendent of the Coast Survey, this Hydrographic Office is not only supplying corrected charts to the vessels of the Navy, but is collecting information as to ice which endangers every ship or steamer of the great lines which connect our Northern ports with Great Britain and France, and it also publishes constantly information as to changes in lights and buoys and discoveries by all nations of shoals and dangers not laid down upon the charts in common use. It publishes at short intervals, not only printed information by bulletin sent to commercial centers in this country, but pilot charts, especially of the North Atlantic, giving the latest intelligence in regard to currents and winds, and the location, when last seen, of all floating wrecks and derelicts, and of the icebergs and other floating ice which, through the whole spring, summer, and fall seasons, lie along the eastern edge of the Great Banks, directly in the track followed by hundreds of steamers and sailing vessels, carrying many thousands of travelers, passengers, and immigrants, and the millions of dollars of our exports and imports.

This work of the Hydrographic Office is evidently of great value and importance to our commercial and business interests, and must save many vessels from wreck, and many lives from destruction. Naval vessels, under direction and instruction of the Hydrographic Office, also survey foreign coasts and unsurveyed harbors and channels, aiding powerfully in the extension and introduction of our commerce to such coasts and harbors, and they contribute to the knowledge of the earth and its inhabitants by deep-sea soundings, by observations of the currents and winds and storms, and of the bottom of the ocean and of its shores.

While this work is scientific work, your committee is not prepared to recommend that it be detached in any way from the control of the Navy Department; nor can they recommend that the hydrographic work of the Coast Survey, for over forty years conducted so satisfactorily under the civil control of the Coast Survey, be separated from that organization before the original survey shall be completed. After that is done, perhaps the work of re-sounding, of re-examining may, without injury to the service, be committed to the control of the Navy Department. Yet, even then, correction and revision of the Coast Survey charts will require some co-ordination, some authoritative connection between the Coast Survey Office and the parties and vessels engaged in these re-examinations for correction of our coast charts.

From the terms of the act under which your committee is considering this subject, it may be inferred that the principal question affecting the Hydrographic Office, on which an opinion is desired, is that of its consolidation with the hydrographic work of the Coast Survey. The reasons for the consolidation of these two works under the Navy Department have been urged with force by the Secretary of the Navy in his last two annual reports. But there are also cogent reasons on the other side of this question. The Coast Survey was specially organized to secure the harmonious co-operation of civilians, officers of the Navy, and officers of the Army, each in his own department, and yet in a single well co-ordinated work. No scientific department of the Government has worked more successfully through the forty years in which this organization has been in operation. Each of the three branches, thus harmoniously co-operating, has received the benefit of the skill and professional experience of the other.

An organization of this sort should not, while its work is going on, be disrupted, except for very strong reasons affecting its efficiency. We would also advert, in illustration of the advantages which our military and naval officers have derived from their connection with the Coast Survey, to the brilliant list of military and naval men during the civil war who derived a very important part of their professional training from their experience on that work. Such a list would include an array of professional leaders which it would be difficult to collect from any other associated body of men. We suggest the names of Porter, the Rodgerses, of Meade, and of Humphreys. Many others might be added, who, after service on the Coast Survey, rose to high employments in the Army and Navy.

While, therefore, your committee are not prepared at the present time to recommend the proposed consolidation, we do not conceive that Congress should adopt measures looking to the separation in perpetuity of the two branches under consideration. The policy of the Coast Survey should, we conceive, be directed towards the completion, at the earliest possible date, of the survey of our coast line; its main operations will thereafter be confined principally to the interior, and then the policy of consolidating its hydrography with the work of the naval hydrographic office will be open for consideration.

We are therefore of opinion that the Hydrographic Office of the Navy Department is worked with all due efficiency as it is now organized, and that no change is at present necessary in its relations to the Government.

Preliminary to our recommendations as to the other three works upon which your committee is called upon to report, it desires to present some general views respecting the working of the departments of the Government.

We conceive it desirable that there should be a clear understanding as to what sorts of scientific investigation may be undertaken by Government organizations. We conceive it to be a sound principle that Congress should not undertake any work which can be equally well done by the enterprise of individual investigators. Our leading universities are constantly increasing the means of scientific research by their professors and students; and while the Government may with propriety encourage and co-operate with them there is no reason why it should compete with them. The scientific work of the Government ought not, therefore, to be such as can be undertaken by individuals. It should also be confined to the increase and systematization of knowledge tending "to promote the general welfare" of the country. Within these two restrictions, there is a large and increasing field which is only partly occupied by the organizations now under consideration. In considering the limits of their functions, your committee, as one of scientists, and not of constitutional lawyers, naturally confine themselves to considerations affecting the general welfare.

The General Government having commenced a general trigonometrical survey of the United States on a large scale under organizations much more efficient in their action than those which any single State can provide, we conceive it desirable that the work thus undertaken should be continued at least to the point at which it can be advantageously taken up by the States themselves. At what precise limit the General Government should stop, we are not prepared to decide, nor is it necessary that this limit should be defined at present. The attention of Congress should also be directed to the fact that the administration of a scientific bureau or department involves greater difficulties than that of a purely business department. The connections between the work done, and the results ultimately to be attained for the public, are not at all obvious to the people and press, and thus the great benefit of vigilant watching and constant criticism is wanting. Again, its administration requires a combination of scientific knowledge with administrative ability, which is more difficult to command than either of these qualities separately. These difficulties are intensified by the absence of any central authority to control the work of a Government scientific organization. Each head of a scientific organization is now, practically, absolutely independent, and, in his individual judgment of what his organization shall do, is controlled only by Congress itself, acting only through its annual appropriation bills. We conceive that this state of things calls for measures of reform.

A feature of such reform will be the collection of the organizations now under consideration together, with such other scientific bureaus as Congress may see fit to include in the scheme, under one central authority, to be recognized as responsible for, and controlling generally the scientific operations of the Government. Various forms of such an authority might be devised, the choice of which will some day be made by Congress. The best form would be, perhaps, the establishment of a Department of Science, the head of which should be an administrator familiar with scientific affairs, but not necessarily an investigator in any special branch.

DEPARTMENT OF SCIENCE.

Your committee states only the general sentiment and wish of men of science, when it says that its members believe the time is near when the country will demand the institution of a branch of the executive Government devoted especially to the direction and control of all the purely scientific work of the Government. In this day, the pursuit of science itself is, visibly to all men of education, directly connected with the promotion of the general welfare. The art of photography, beginning in 1802, with the scientific experiments of Wedgwood, has developed till, in this country alone, the annual value of photographs produced is estimated at thirty millions of dollars. The study of electricity has resulted in the telegraph, the telephone, the electric light, the electric railway, some of which results count their revenue by millions, and have created already within a few years of their discovery properties employing the capital of hundreds of millions.

None who have lived with open eyes during the development of these results of purely scientific investigation doubt that the cultivation of science "promotes the general welfare."

Should such a Department be now impracticable, should public opinion not be now ready for it, the next best measure, in the opinion of scientific men, would be to transfer all such work or bureaus to some one Executive Department. Keeping in mind what has been said respecting the two classes of work under the Signal Service, we are of opinion that the functions of the several organizations under consideration could now be most advantageously divided among perhaps four bureaus, namely:

1. The Coast and Interior Survey, to be concerned principally with geodesy and hydrography, and to consist of the present Coast and Geodetic Survey.
2. The Geological Survey, to comprise the present Geological Survey with its organization unchanged.
3. The Meteorological Bureau, to which should be transferred so much of the present *personnel* and functions of the Chief Signal Office as are not necessary to the military duties of that office.
4. A physical observatory, to investigate the laws of solar and terrestrial radiation and their application to meteorology with such other investigations in exact science as the Government might assign to it. In this connection, attention is called to a resolution passed by the recent Electrical Conference in Philadelphia requesting the establishment, the Government, of a bureau of electrical standards. We are of

opinion that the functions of the Bureau of Weights and Measures, now performed by the Coast Survey, could be advantageously transferred to the proposed bureau, and extended so as to include electrical measures.

The members of your committee are conscious that placing these bureaus under one Department would not necessarily result in the proper co-ordination of their work, because the head of such Department would probably find it impracticable to enter into the consideration of all details necessary to that purpose. It appears to us that the evils already pointed out require in any case the organization of a permanent commission to prescribe a general policy for each of these bureaus. The functions of this commission would be—

I. To examine, improve, and approve the plans of work proposed by the several bureaus, and to revise their estimates in accordance with such plan. The performance of this duty would require consultation with their chiefs generally and separately, respecting the character of their work, and they should be members of the commission.

II. To approve in detail the methods of expenditure of the appropriations.

III. To recommend such measures as they deem necessary to the efficiency of the bureaus under their supervision. It should, however, be understood that this commission is not charged with purely administrative responsibility.

It prescribes what shall be done, and recommends any measures necessary to secure that object, but does not concern itself with administrative details.

We submit the following as a suggestion for the formation and *personnel* of such a commission.

The commission shall consist of (1) the President of the National Academy of Sciences; (2) the Secretary of the Smithsonian Institution; (3 and 4) two civilians of high scientific reputation, not otherwise in the Government service, to be appointed by the President of the United States, for the term of six years; (5) one officer of the Corps of Engineers of the United States Army; (6) one professor of mathematics in the Navy, skilled in astronomy, these two to be designated by the President of the United States for a term of six years, who, with (7) the Superintendent of the Coast and Geodetic Survey, (8) the Director of the Geological Survey, and (9) the officer in charge of the meteorological service, shall constitute the commission of ———. The Secretary of the ——— Department shall be, *ex officio*, president of the commission.

The members of the commission, for their services as such, shall each be paid by the United States compensation in the sum of ——— dollars per annum. Their necessary transportation and traveling expenses shall be provided for as are those of officers of the Army and Navy when traveling on public business or duty, to be paid out of the appropriations for the services under their supervision.

The commission shall meet in Washington, D. C., for the transaction of business, not less than four times a year. But the president of the commission may convene it whenever, in his judgment, the exigencies of the service require a meeting.

The commission shall be attached to the office of the Secretary of the Department of ———, and, under his superintendence, shall exercise a general control over the plans of work of the United States Coast and Geodetic Survey, the United States Geological Survey, and the meteorological service, and shall have the charge and custody of all the archives, books, documents, drawing, models, returns, apparatus, instruments, and all other things appertaining to the commission.

The estimates of the heads of these bureaus or offices shall pass through the commission for revision and approval, and, after the annual appropriations have been made, no money shall be expended under them, except after revision and approval by the commission of projects submitted by these bureaus in compliance with such projects.

If at any time public money is being spent by any of these bureaus not in accordance with the views of the commission, the commission shall notify the proper auditor of the fact.

Respectfully submitted.

M. C. MEIGS,
Chairman of Committee.
WM. H. BREWER.
W. P. TROWBRIDGE.
E. C. PICKERING.
C. A. YOUNG.
FRANCIS A. WALKER.
S. P. LANGLEY.

WASHINGTON, D. C., *September* 21, 1884.

APPENDIX.

Letters from the Signal Office.

SIGNAL OFFICE, WAR DEPARTMENT,
Washington City, September 16, 1884.

General C. B. COMSTOCK, *U. S. Army,*
Secretary Committee of National Academy of Sciences :

DEAR SIR : In reply to your letter of the 10th instant, requesting me substantially to state what is necessary for "the best organization of the Signal Service, the duties which it should perform, its relations to other scientific branches of the public service, and other matters relating to the subject which may occur" to me, I have the honor to express my decided opinions, based upon long observation and careful study, that no other than a military organization can secure that prompt and unbroken series of observations and reports which alone give the highest value to forecasts of weather and other branches of our meteorological work, and such is the testimony of all foreign meteorological authorities whose opinion I have learned.

The branch of duties known as military signaling, which has now become indispensable in all armies, must of course have a military organization. Now, the one organization performs both duties, while, were the meteorological part to be performed by a civil one, the present organization, or its equivalent, would be needed for this work alone, while the military signal service would be wholly additional.

The system now in use by this Government, surpassing as it does all others, and which is the result of fourteen years' experience and study and the expenditure of millions of money, would be wholly unsuited to any plan but a military one, and to attempt to transfer or change it would be the loss of system and plan, and a long step backward, even if it could finally succeed, which, without the obligations of regular enlistment and military discipline, it is believed it cannot do.

In order that the Signal Service shall carry on all its present work efficiently, its *personnel* cannot be reduced either in numbers or grade, nor ought any of its work to be abandoned; and saving in money can be effected only by more economical methods of administration.

This can come only in one way; that is, by completing its present partial organization. As is well known, the Signal Corps, so far as it is an organization at all, has been built up step by step, according to a regular plan, till now it has head and feet, the former with the rank of brigadier-general and the latter of second lieutenant, the unfinished part being the intermediate grades. These have not yet been created, but the time has fully arrived for making them. These intermediate grades are now filled by temporary details from the line of the Army, and, before the officers detailed are fully familiar with their duties as signal officers, their colonels begin calling for them to go back to their regiments, which calls finally prevail.

By this means, a large proportion of the time of these officers is consumed in getting ready for duty, and when they have become fully instructed and useful, they, with their valuable and costly experience, are lost to the Signal Service. In this way, there is a great waste, not only of time, which costs money, but in money itself, because, like the work of an inexperienced mechanic, there is much waste of material.

The needs of the Signal Service, then, make it imperative that the intermediate grades of field officers, captains, and first lieutenants be now made, not only on the score of efficiency, but of economy, and this is especially necessary at this time, since Congress has adopted the plan of sending two officers of experience back to their regiments whenever two sergeants of the Signal Corps are promoted to be second lieutenants. Economies many times greater than the additional cost for salaries can be effected by a completed organization.

It will be seen from papers already furnished, that in four years the expenditures of the Signal Service have been reduced, till now there is a saving of about $327,000 annually over what it cost when I assumed the office of Chief Signal Officer. Quite a large proportion of this extra expenditure was through extravagant methods that probably would not have been adopted had the expenditures always been made by experienced officers of the Signal Corps. Scarcely a month has passed but some leak has been discovered and stopped, where money was unnecessarily spent, not corruptly, but from inexperience and lack of that close and intelligent attention to duty which springs from a wholesome *esprit du corps.*

The easy plan in the line of economy, which will give efficiency to the Service, is to complete the organization of the Signal Corps. The legislation necessary to do it is sketched in an accompanying paper.

A considerable economy can also be effected, while it will give safe storage to the vast accumulation of meteorological records, almost invaluable, and now greatly exposed to damage by fire, by building a suitable office for the Signal Corps. The amount for rents now, and for years past, is $7,000, while the needs for the next year will require $800 additional; and, since the different branches of the office are scattered and located in nine distinct and separate buildings, some $3,000 a year is now paid to messengers and porters, which would then be saved. This makes a cost of $10,800, while a new office, better adapted in every way to our purposes, and which would give safety to the records, could be built, with cost of site, for $300,000, or at an annual interest, at 3 per cent., of $9,000, giving an annual saving of $1,800.

These are the chief ways in which large savings can be made, while largely benefiting the service.

These are but a part of the advantages to be derived from a completed organization, the chief one being, like that of a permanent staff everywhere, a better general administration.

I have no doubt but that, had I had an organized corps, with officers of my own, whose points I fully knew, the disaster that overtook the Greely Relief Expedition of 1883 would not have occurred. The want of such a corps is felt every day, and it is hoped that Congress will no longer withhold its benefits, leaving it alone, of all services in the Army, weakened and embarrassed by the want of organization.

I have here pointed out what appears to me the best organization of the Signal Service, based upon all the experiences and observations of this and other Governments.

I do not think it should be related in any way to other scientific branches of the public service, except in amity and courteous co-operation when opportunities occur, its work being entirely unique and separate, while its duties should be just what they are now, meteorological and military signaling, endeavoring in every possible way to develop the former, and improve the latter. This is enough work for one bureau.

For a year, one of the professors of this corps, Mr. Waldo, by my direction, pursued the studies of the various branches of meteorological science in the best schools of Europe, becoming well acquainted with their progress and methods. I inclose his opinions upon the subject, and also those of Lieutenant Ray, U. S. A , who represented me at the International Polar Conference at Vienna last March, where he met the leading meteorologists of foreign countries.

I am, very respectfully, your obedient servant,

W. B. HAZEN,
Brig. and Bvt. Maj. Gen., Chief Signal Officer, U. S. A.

SIGNAL OFFICE, WAR DEPARTMENT,
Washington City, September 17, 1884.

Maj. Gen. M. C. MEIGS, *U. S. Army,*
Chairman Committee of National Academy of Sciences:

DEAR SIR: In reply to your letter of August 14, I would respectfully state that most of the information desired will be found in the inclosed copies and publications.

1. The letter to General Comstock, secretary of the committee of which you are chairman (copy inclosed), contains much that otherwise would be written here. Its reading will be necessary to make complete what I desire to communicate.

2. The pamphlet setting forth the needs of a completed organization for the Signal Corps, I call special attention to. The present plan of sending away to their regiments officers who have gained great experience is a constant loss, which no corps of men can suffer and hope to gain the highest efficiency.

It is traditional that all, or nearly all, meteorological records of value, from the prime necessity of continuity, and the necessity of firmly holding the observers, have been kept by some order of military men. This need is now shown.

3. The statutes and general legislation on which the Signal Service stands are fully given.

4. The scheme and rules for the Signal Service school at Fort Myer, Virginia. This school has received and is receiving very full and careful attention.

5. A copy of the last annual report, from which can be readily gathered principal features of the current work of the Signal Corps. In addition, since this report was written, a plan for giving the approach of "cold waves" by flags has been adopted

and received with marked favor, as in some cases has the plan of giving the probable changes of weather along lines of railroads by a system of colored disks, displayed on the moving trains.

The subject of earth currents of electricity in their relations to the weather has also been taken up within the last year.

6. The annual report for 1882, with appendices, showing this work more fully.

7. A full series of the current publications of the office. (Copies of these are sent to the chairman and secretary only.)

8. A list of publications of the Signal Service since the present Chief Signal Officer has controlled it, printed and in press.

The service now has a proficient and distinguished corps of professors, who have begun the work of original investigations upon this almost new work, the domain of meteorology.

10. A list of foreign meteorological bureaus.

For a short account of them, I refer to Professor Waldo's statement. By my direction, he investigated for a year foreign meteorology, as studied and applied at the best seminaries in Europe I also call attention to the statement of Lieutenant Ray, on page 10, No. 2, inclosed papers, who represented the Chief Signal Officer at the late conference of the International Polar Commission at Vienna, where he met the directors of the chief meteorological bureaus of the world.

In comparing the services of different nations, attention is invited to the radical difference in purpose between the Signal Service of the United States and the services in foreign countries. It will be seen by the character of nearly all the legislation relating to the United States service since the joint resolution of February 9, 1870, that the prime object has always been to "give warning of the approach and force of storms," and that the specific object for which the appropriations have annually been made has been the immediate and current benefits arising from the "observation and report of storms." The benefits of the first legislative action extended only to the sea and lake coasts; but the results accomplished were so favorable, and the public benefits so considerable, that it was soon found necessary to extend the system of warnings and predictions, so as to more directly reach the great agricultural interests, such as cotton, sugar-cane, tobacco, corn, and fruit and vegetable-growing, and stock-raising. So entirely have the money, time, and labor of the service been required to meet the public demands in this respect, viz, current observations and reports in the way of bulletins and predictions, that little has been left for climatological work or research.

The services of most European governments, from the very nature of their geographical situations, have been established more for purposes of climatology, and scientific research and discussion, than for the current publication of observations and predictions. In most European countries, the meteorological work done is of use only to scientific men, and then only after years of study and discussion. In the United States, the Signal Service bulletins and publishes thrice daily, by its admirably trained and disciplined corps of observers, its meteorological reports for the entire country, within one to two and a half hours of the time of observation, in hundreds of the principal cities and ports, and the intelligent and educated American public daily uses these reports in nearly every branch of human industry, occupation, and pursuit. The little that is published in the way of daily reports and predictions in European countries reaches the public too late to be of much practical use, owing to causes which do not exist in the United States, where all the observers are directly under one head, and act with the vigilance, celerity, and certainty, which, only the true military system can attain. I doubt if there is anything in any of these services that could be advantageously incorporated into our own.

11. A statement of the comparative cost of the Signal Service now and four years ago. During this period, the practical work of the Signal Service has been nearly doubled, and its methods and work have been improved in every way. A few copies of current publications of the former period are inclosed for comparison.

12. A statement showing more specifically the objects to which the appropriations for the Signal Service are directed.

13. A statement of the relative cost of the Weather Bureau under its present military organization and a civil one.

14. History of the Signal Service, with a list of signal stations. (This paper is not quite ready, and will be sent later.)

I would prefer to answer only as regards the Signal Corps, and I can see no advantage in connecting it with any other scientific corps.

I have already very fully stated how, in my opinion, it would be very desirable to complete the organization of the Signal Corps.

I am, very respectfully, your obedient servant,

W. B. HAZEN,
Brig. and Bvt. Maj. Gen'l, Chief Signal Officer, U. S. A.

Letter from the Director of the Geological Survey.

HOTEL LAFAYETTE,
Philadelphia, September 8, 1884.

SIR: I have the honor to acknowledge the receipt of your letter as chairman of the committee of the National Academy of Sciences, requesting from me a statement of the organization of the United States Geological Survey, and an outline of its operations. The following is a reply thereto:

I. The organization under my direction is prosecuting a topographic survey of the United States under authority of law. For this purpose, it is executing a triangulation of the United States sufficiently refined for cartographic purposes, but not more refined than is necessary for the construction of good maps. In connection with this work, there is, first, an astronomic and computing division, the officers of which are engaged in determining the geographic co-ordinates of certain primary points; second, a trigonometric corps, engaged in expanding a system of triangulation over various portions of the country from measured base-lines; third, a topographic corps, organized for the purpose of prosecuting a topographic survey from the points previously determined by the astronomic and trigonometric divisions. This topographic corps is organized into twenty-seven parties, scattered in various portions of the United States. The topographic work is not everywhere carried on by the same methods, but the methods are somewhat diversified, depending upon the characteristics of the country surveyed, and the scale on which the maps are to be constructed. It is believed that this work should be more refined and elaborate in some portions of the country than in others, and the methods of survey in a level country necessarily differ from the methods to be pursued in a country of high and mountainous reliefs. Again, there are portions of the United States devoid of timber, and other portions densely wooded, and, in these districts, diverse methods must be adopted. And still other reasons demand a variety of methods. The scale adopted for the general work varies from $\frac{1}{250000}$ to $\frac{1}{62500}$. It is believed that the triangulation and topographic field-work are carried on with a degree of refinement sufficient for the scale adopted; that is, determinations of positions and altitudes are made with all the approximation to accuracy that it is possible to utilize in representing the field-work on paper.

II. With topographic maps constructed as above, a geologic survey is prosecuted in the field, embracing the subjects of areal and structural geology; that is, this survey is conducted for the purpose of exhibiting the geographic distribution of geologic formations, and plotting the same upon charts, and, at the same time, the structural geology of the formations is studied, and the materials collected in the field are plotted in geologic sections. While engaged in this field-work this corps of geologists collects fossils, minerals, ores, and rocks, for further study in the laboratories of the survey.

III. There are in the Survey three distinct corps of geologists engaged in the study of economic geology, at the present time relating especially to gold, silver, copper, iron, coal, and quicksilver.

IV. There are in the Survey, as at present organized, the following paleontologic laboratories:

(*a.*) A laboratory of vertebrate paleontology for formations older than the Quaternary. In connection with this laboratory, there is a corps of paleontologists.

(*b.*) There is a laboratory of invertebrate paleontology of Quaternary age, with a corps of paleontologists.

(*c.*) There is a laboratory of invertebrate paleontology of Cenozoic and Mesozoic age, with a corps of paleontologists.

(*d.*) There is a laboratory for invertebrate paleontology of Paleozoic age, with a corps of paleontologists.

(*e.*) There is a laboratory of paleobotany, with a corps of paleobotanists.

The paleontologists and paleobotanists connected with the laboratories above described, study and discuss in reports the fossils collected by the general geologists in the field. They also supplement the work of the field geologists by making special collections in important districts and at critical horizons; but the paleontologists are not held responsible for areal and structural geology on the one hand, and the geologists are not held responsible for paleontology on the other. In addition to the large number of paleontologists on the regular work of the Geological Survey, as above described, several paleontologists are engaged from time to time to make special studies.

V. There is a chemical laboratory attached to the Survey, with a large corps of chemists engaged in a great variety of researches relating to the constitution of waters, minerals, ores, and rocks.

VI. There is a lithologic laboratory in the Survey, with a large corps of lithologists engaged in the microscopic study of rocks.

VII. There is a physical laboratory in the Survey, with a small corps of men engaged in certain physical researches of prime importance to geologic philosophy.

VIII. There is in the Survey a division of illustration, organized for the purpose of preparing illustrations for paleontologic and geologic reports.

IX. There is in the Survey an extensive geologic library, and the librarian has a corps of assistants engaged in bibliography.

X. There is in the Survey a division of mineral statistics, with a large corps of men engaged in statistical work, the results of which are published in an annual report entitled "Mineral Resources."

With the organization above indicated, a general topographic and geologic survey of the United States is in progress, and the officers of the Survey at the present time are widely scattered throughout the country.

The topographic survey of the United States properly commenced about the year 1870, under the four organizations that were subsequently consolidated so as to constitute the present United States Geological Survey. The work has been continued under the present organization by methods more elaborate and refined. The total area topographically surveyed at the close of the present field season will be something more than 600,000 square miles. In the prosecution of this work, the triangulation of the Coast and Geodetic Survey, the triangulation of the Lake surveys, and various other geographic works prosecuted by the General Government, and by the several States, and by private enterprise are utilized to the greatest possible extent. In general geology, the work heretofore done by the General Government, and by the several State governments, and by various individuals is also utilized to the greatest possible degree.

In connection with the general survey embracing topography, general geology, and mining geology, certain great economic problems are under investigation. The most important of these relates to the irrigation of the arid portions of the United States. The second question of importance relates to the relief which will be afforded to the lower valley of the Mississippi by utilizing the waters that flow from the Rocky Mountains on the west, and the great plains in irrigation. A third problem of great importance relates to the distribution of the forest areas of the country.

The organization and operations of the Survey are thus briefly set forth, in compliance with your request.

I beg permission to make a request, viz: That I may be permitted to present to the committee of the Academy over which you preside, certain opinions relating to the organization of the scientific work of the Government, on a comprehensive plan, by which the work can be more thoroughly co-ordinated, more systematically prosecuted, and more economically administered than at present, and to present the facts on which these opinions are founded. I beg permission also to state that I should esteem it a pleasure to answer any further inquiries, to any desired extent of detail, which the committee may wish to propound.

I am, with great respect, your obedient servant,

J. W. POWELL.

General M. C. MEIGS,
Chairman Committee National Academy Sciences, Washington, D. C.

Reply of the Superintendent of the Coast and Geodetic Survey to the inquiries of the chairman of the committee of the National Academy of Sciences.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, September 19, 1884.

DEAR SIR: In compliance with your invitation through the Secretary of the Treasury under date of August 14, I communicate herewith the following statement in regard to the organization of the Coast and Geodetic Survey, and the present condition of the work, for the information of your committee.

HISTORICAL SKETCH.

A systematic survey of the coast was first inaugurated by the act of Congress of February 10, 1807, which read as follows:

"AN ACT to provide for surveying the coast of the United States.

"*Be it enacted, &c.*, That the President of the United States shall be, and he is hereby, authorized and requested to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or headlands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coast within the extent aforesaid."

The work was assigned to the direction of the Treasury Department, where it continued until 1817, when the bill making appropriations for the work contained a proviso that the survey should be conducted only by naval officers. The work, then just fairly inaugurated, was thus discontinued as a separate organization, and only disconnected surveys were made as opportunity or occasion presented. Such discord and dissatisfaction resulted from the want of system that in 1832, July 10, the survey was reorganized by the following act:

"AN ACT to carry into effect the act to provide for a survey of the coast of the United States.

"SECTION 1. *Be it enacted, &c.*, That for carrying into effect the act entitled 'An act to provide for surveying the coasts of the United States,' approved on the 10th day of February, 1807, there shall be, and hereby is, appropriated a sum not exceeding twenty thousand dollars, to be paid out of any money in the Treasury not otherwise appropriated; and the said act is hereby revived, and shall be deemed to provide for the survey of the coasts of Florida, in the same manner as if the same had been named therein.

"SEC. 2. That the President of the United States be, and he is hereby, authorized, in and about the execution of the said act, to use all maps, charts, books, instruments, and apparatus which now, or hereafter, may belong to the United States, and employ all persons in the land or naval service of the United States, and such astronomers and other persons as he shall deem proper."

Upon reorganization, the conduct of the work was assigned to the Treasury Department. In 1834, it was transferred, as an organization, to the Navy Department (by Executive order, the matter being then within the functions of the President), but the extreme difficulty of conducting such work under other than a civil organization was so forcibly shown that after two years' trial it was retransferred to the Treasury Department, where it has since remained.

The question of assignment to the Navy Department being constantly agitated Congress, in 1843, provided for an examination into and settlement of the matter by the following act of March 3, 1843:

"AN ACT making appropriations for year ending June 30, 1844.

"For survey of the coast of the United States, including compensation of Superintendent and assistants, one hundred thousand dollars: *Provided*, That this, and all other appropriations hereafter to be made for this work, shall, until otherwise provided by law, be expended in accordance with a plan of reorganizing the mode of executing the survey to be submitted to the President of the United States by a board of officers which shall be organized by him, to consist of the present Superintendent, his two principal assistants, and the two naval officers now in charge of the hydrographical parties, and four from among the principal officers of the Corps of Topographical Engineers; none of whom shall receive any additional compensation whatever for this service, and who shall sit as soon as organized. And the President of the United States shall adopt and carry into effect the plan of said board, as agreed upon by a majority of its members. And the plan of said board shall cause to be employed as many officers of the Army and Navy of the United States as will be compatible with the successful prosecution of the work; the officers of the Navy to be employed on the hydrographical parts, and the officers of the Army on the topographical parts of the work; and no officer of the Army or Navy shall hereafter receive any extra pay out of this, or any future appropriations for surveys."

After discussing the matter, outlining the methods, and defining the duties of those employed, the Board adopted the following resolution, expressive of their opinion as to which Department should have control of the work:

"*Resolved*, That inasmuch as the object and purpose of the Survey of the coast refer principally to the commercial interests of the country, and as all the laws of Congress in relation to the same contemplate the employment of civilians and officers of the Army and Navy upon said work, it is the opinion of this Board, and they do hereby respectfully recommend, that it should be under the control, and considered a part of the Treasury Department."

The plan of organization submitted by the Board received the President's approval and became operative on April 29, 1843, and has been since then the basis upon which the Survey has been conducted.

In the spring of 1848, an attempt was again made in Congress to transfer the Survey to the Navy Department. It was defeated in the House by a vote of 90 to 36. In the spring of 1849, in the Senate, Mr. Benton moved to amend the civil bill as it came from the House by reducing the amount appropriated for the Coast Survey, and adding the words "the said Survey shall be carried on exclusively by the Navy Department, under the direction of the President of the United States." After a full discussion, the amendment was lost, only two Senators voting for it.

On December 31, 1850, a resolution of the Senate called upon the Secretary of the Navy to report what advantages would be derived by a transfer of the Coast Survey to the Navy Department, and upon the Secretary of the Treasury to state why, in his opinion, such transfer should not be made. Their replies are printed as Senate Ex. Docs. Nos. 35 and 36, Thirty-first Congress, second session (15 February, 1851). The arguments in favor of transfer were not considered of sufficient weight to warrant any change. The propriety of maintaining the Survey as a distinctive civil organization then became so generally recognized that no further serious attempt was made for many years.

In 1871 (act of March 3), the field operations of the Coast Survey were extended so as to include the execution of a primary triangulation across the continent to form a geodetic connection between the Atlantic and Pacific coasts. The same bill authorized the extending of aid to States for the survey of their territory, by the following clause:

"*Provided*, That the triangulation shall determine points in each State of the Union which shall make requisite provisions for its own topographical and geological surveys."

Under the provisions of this last clause, eleven States have inaugurated surveys which are now in active prosecution under direction of the Coast and Geodetic Survey.

With this enlargement of the functions of the Survey, its name was changed to the United States Coast and Geodetic Survey.

In 1878, a clause of the sundry civil bill (June 30) read as follows: "And the National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, documents, and other results of the said surveys."

Their report (H. R. Mis. Doc. No. 5, Forty-fifth Congress, third session, December 3, 1878) recommends the consolidation of all surveys of mensuration under one head; has carefully considered the various questions, and believes that the Coast and Geodetic Survey is practically best prepared to execute the entire mensuration system required, and suggests such consolidation under the Coast and Geodetic Survey, its name to be changed to the Coast and Interior Survey.

At the same time, it recommended the establishment of an independent organization, to be known as the United States Geological Survey, to be charged with the duty of examining into the geological structure, natural resources, and production of the public domain, but that no surveys of mensuration be made by it other than local topographical surveys for development of special mineral deposits.

The recommendations of the Academy were so far adopted as to leave the Coast and Geodetic Survey in charge of the survey of the coast, and of the State surveys and interior geodetic work, to discontinue the various geological and geographical surveys, and to organize the United States Geological Survey, charging it with the duties specified by the Academy. Its functions were to be confined to geology and not to embrace geodesy (sundry civil bill, March 3, 1879).

In his annual message to Congress, presented in December, 1882, the Secretary of the Navy recommended the transfer to his Department of the Coast and Geodetic Survey, the Revenue Marine, the Life-Saving Service, the Light-House Board, and other bureaus of the Treasury Department. The heads of the various bureaus named were invited by the Secretary of the Treasury to make such statements in regard to the proposal as should seem advisable. Their replies were published as Treasury Doc. No. 395 (January, 1883), and the arguments presented in opposition to the transfer of any of the bureaus were such that no action was taken.

From the foregoing it will appear that the present organization of the Coast and Geodetic Survey may be briefly stated as follows:

Its organization provides for a survey of the coasts of the United States upon the basis of a trigonometrical survey, as set forth in the act of 1843.

In 1871, the extension of the triangulation to a line reaching across the continent, and connecting the surveys of the Atlantic and Pacific coasts was authorized, as well as the supplying of points for State surveys in such States as provided for a topographical or geological survey of their area. This had underlying the idea of an ultimate trigonometrical survey of the whole area of the country, giving natural precedence to those regions where circumstances most called for such work. The views which have guided my predecessor and myself in this shaping of the future of the work were expressed by me in the subjoined letter to the chairman of the House Committee on Appropriations in 1882:

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, May 2, 1882.

SIR: In compliance with your request, I submit a statement of the scientific objects and practical usefulness of the work carried on for some years past by this office, under the designation of "triangulation to connect the Atlantic and Pacific coasts," and "determination of points in aid of State surveys."

That work was first authorized in the appropriation bill for the year 1871–'72,* and with slight variations in the terms of appropriation, simplifying the statement, has been provided for ever since.

The immediate object of the geodetic connection, or transcontinental triangulation, is to ascertain accurately the distance between some points on the two coasts, and their relative positions on the surface of the earth. This requires the same operations of base measure and triangulation, and, at frequent points, observations of latitude, longitude, and direction of the meridian, as are made for the surveys of the coasts.

By this means we obtain, in addition to the separate surveys of the coasts proper, a connecting link, which gives for a general map of the whole country a known skeleton or framework.

Such a connecting link is a necessary and proper part of a survey of the "coasts and adjacent islands, &c., of the United States," as originally provided for by law, in order to bring into harmony the measurements along the Atlantic and Pacific coasts. This is sufficiently obvious to allow us to believe that it would have been specified in the original law if the country had, at the time of its enactment (1807), had a "western coast." In fact, the terms of section 4681 (Revised Statutes) require no straining to be applied to the ascertainment of the distance and direction between Cape Cod and Cape Mendocino, or between Sandy Hook and the Golden Gate.

In addition to this requisite purpose of the transcontinental line of survey, it presents the following scientific and practical advantages, viz:

SCIENTIFIC RESULTS.

It accomplishes incidentally—

1st. The measurement of an east-and-west line of about three thousand miles, the curvature of which is determined by the longitude observations, and thus contributes by far the longest arc of a parallel that has been measured for the determination of the size and figure of the earth, just as the survey of the coast contributes, incidentally, important meridional measurements.

2d. The accurate determination of the height above the sea level of a great number of points along the line, affording a common datum plane for all elevations across the continent, and also ascertaining the relation of the mean level of the ocean on the eastern and western coasts.

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* *See page 10*, Laws and Regulations Coast and Geodetic Survey.

PRACTICAL ADVANTAGES.

The transcontinental link furnishes accurate base lines for all State surveys within its range, and puts into position the (so-called) meridians and base lines of the public land survey wherever it intersects them. Such surveys as now exist are irreconcilable, frequently by many miles. The best maps of the States of Ohio, Indiana, and Kentucky, constructed upon independent data, when put together, leave no delineation of the Ohio River. Between the land survey maps of Illinois and Missouri, the Mississippi River presents in places wide lakes, in others, it entirely disappears.

Without some outside check, no property surveys can be combined into a town map, no town surveys can be combined into county maps, no county surveys can be combined into a State map. A map of a State constructed upon such a basis will be widely in error, while that of a State constructed upon the reverse method; viz., a system of some accurately ascertained points, from which one or more points in every county are derived by triangulation, will possess all the essentials of correctness.

In the foregoing considerations, except so far as the direct connection between the surveys of the Atlantic and Pacific coasts is concerned, there is underlying the general idea that in time it will become necessary to have a correct map of the whole area of the United States.

The detail of such a map may properly be constructed by each State as their necessity and convenience may require. The situation in regard to Government surveys of the several States differs very much according to their history, the more recent States having been parceled out according to the system of the public land surveys, which furnish at the charge of the General Government at least an approximate map of the most important features of the country, while the older States have had no such benefit.

A simple framework of points from 15 to 25 miles apart within which all local surveys must rigorously fit is all that is requisite to bring harmony into what is now utter confusion.

Such is the work now in progress in nine States, under the recital of the general appropriation for the United States Coast and Geodetic Survey: "Furnishing points for State surveys."

Leaving to each State the care of making provision for detailed surveys of boundaries and properties within its limits, or for topographical and economic purposes at such times as their occasions may demand, it remains evident that a general framework of accurate distances and bearings between intervisible points covering the whole country is necessary to secure unity and harmony in all its parts.

This general framework is necessarily a national work. It is not proposed to press it forward in advance of the requirements of the times, but with reasonable foresight to have it in hand for the inevitable demand.

Mr. Chairman, I will not expand further the statement which you have given me the opportunity of making, but will only add the statistical facts that within recent years about $30,000 have been expended annually upon triangulation between the Eastern and Western coasts, and about $15,000 for aid to State surveys distributed in nine States. The former object can be completed at the same rate of expenditure in five years; the latter is indefinite in its character, and subject to such expansion as Congress may see fit to give to it from time to time.

I have not referred to the work of this nature that has been done by other nations—even by those of the scantiest resources—because the general facts are too well known to require recital in this brief statement.

Very respectfully,

J. E. HILGARD,
Superintendent.

Hon. Frank Hiscock,
Chairman Committee on Appropriations, House of Representatives.

Moderate appropriations have been granted annually for this class of work; for the transcontinental triangulation about $30,000 (this year only $20,000), and for geodesy for the several State surveys about $14,000. The present status of the work is as follows, approximately stated:

Transcontinental triangulation about three-fifths done.

Surveys in States table prepared June, 1884. (See below.)

States in which triangulation has been carried on under the appropriation "for furnishing points for State surveys," and amounts expended in 1883–'84.

State.	Amount.	Name.	Progress.
New Hampshire	$1,816	Prof. E. T. Quimby	Three-fourths completed.
Vermont	1,210	Prof. V. G. Barbour	One-fourth completed.
New Jersey	2,338	Prof. E. A. Bowser	Two-thirds completed.
Pennsylvania	1,430	Prof. M. Merriman	SE. portion nearly completed.
Tennessee	1,447	Prof. A. H. Buchanan.	One-third completed.
Kentucky	2,005	Prof. J. R. Proctor	Well under way.
Ohio	785	Prof. R. S. Devol	Lately begun.
Indiana	1,496	Prof. J. L. Campbell	Much laid out to be done.
Wisconsin	2,280	Prof. J. E. Davies	Southern border nearly completed and reconstruction of portion of center.

These amounts were allotted last year to each State where the geodetic work was intrusted to some scientific man employed by the State.

The Coast and Geodetic Survey supplies instruments, criticizes and approves estimates, and keeps general control, assimilating the work to its own well established methods and principles. Under its care the work has made good progress in each State.

In regard to the survey of the coast proper, the following statement will give a general view of its condition:

On the Atlantic and Gulf coast the survey is about nine-tenths completed. The changes which take place in the shores and channels, mainly from natural and partly from artificial causes, render resurveys necessary from time to time, in different places, in order to keep the charts and sailing directions up to date. Of the important harbor of New York, the entrance is kept under annual examination in order to keep track of the changes, and, if possible, control their causes. A complete resurvey of the great thoroughfare of Long Island Sound is in progress under special appropriations, as, in time, great changes have taken place, or many localities have very much grown in importance. A complete resurvey of Delaware Bay is just about being finished.

It is evident that even where the whole extent of the coast has once been charted, a considerable amount of work must continually be done in order to maintain the correctness of the charts and "coast pilots" or sailing directions. I estimate that it will require a force of two parties, one ashore and one afloat, in each of five districts between Passamaquoddy Bay and the Rio Grande to keep up this work.

The survey of the Pacific coast between San Diego (the Mexican boundary) and Fuca Straits (with Puget Sound) is about three-fifths done, and the publication of charts, sailing directions, and tide tables is proportionally advanced. The same considerations in regard to future resurveys obtain here equally as on the Atlantic coast. One resurvey of San Francisco Bay has been made some ten years ago, and a new one is now strongly urged.

In the territory of Alaska, no minute or exact surveys have yet been undertaken, as the condition of the country does not yet call for them, but a good deal has been done in the way of geographical exploration and hydrographic reconnaissance. Many charts of approximate correctness have been published as well as a volume of sailing directions.

Mention must not be omitted of the explorations of the Gulf Stream, having for their object the discovery of the laws that govern it, with the view of taking due account of it in navigation, and as an indication of the approach to our shores, as also of the researches into the distribution and laws of change of the earth's magnetism, by which we have been enabled to ascertain the variation of the compass along our coasts, as well as over the whole country—a knowledge equally important to the mariner and to the land-surveyor.

Having thus summarily recited the organization of the Coast and Geodetic Survey, and the present state of the work intrusted to it, I will now offer some remarks upon the second and third questions of the Congressional Commission as to the way in which certain scientific bureaus can best be co-ordinated, and what changes or additions in them are desirable.

So far as the Coast and Geodetic Survey is concerned, it has no relations to the "weather service," and I shall leave it out of consideration.

The questions raised have, in great part, their origin in a recommendation of the Secretary of the Navy, that the administrative direction of the Coast Survey be transferred to his Department. I have endeavored to reply to this proposition in a letter addressed to the Secretary of the Treasury, which is subjoined:

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, January 6, 1883.

SIR: The principal reasons against transferring the Coast Survey Service from the Treasury Department to the Navy Department must necessarily be those which led, in 1843, to the adoption of the present system of administration, together with the fact that the work has been successfully conducted under the same. These considerations may be briefly stated as follows:

The work is one which requires the co-operation of persons specially trained in geodesy or spherical surveying, in trigonometrical and topographical surveying, in nautical surveying and the science of navigation, beside the employment of mathematical computers, skilled draughtsmen, engravers, mechanicians, and other persons of special attainments.

It was believed that an organization composed of such various elements, including civilians, engineer officers of the Army, and officers of the Navy, would be most advantageously placed under a civil Department, where all difficulties arising from questions of relative rank and special privilege would disappear. For this reason, and as relating mainly to the commercial interests of the country, the work was placed under the Treasury Department, which has charge of that part of the public service.

It is claimed and admitted that this plan has worked well, and excellently well. The permanent civil nucleus has preserved unity of plan and methods in the work, has fostered its progress and development, and has maintained the necessary strict co-ordination of the survey afloat with that of the shore.

The spare force of the naval and military service has been utilized to advantage. There are not now any officers of the Army employed in the work, because their whole force is needed in improvements of rivers and harbors. In like manner, at times when the Navy required its whole force for war purposes, not a single naval officer was employed on the Coast Survey. On the contrary, civilians on the work performed duty with the fleets. The case is now reversed, and about fifty naval officers, mostly of lower grades, find useful employment and valuable experience on the Coast Survey. About 250 men are furnished with pay and rations, and the total expenditure on the part of the Navy amounts to about $250,000 a year, being 30 per cent. of the whole expenditure for the Coast and Geodetic Survey. This is made the ground by the Secretary of the Navy for the claim that the work should be transferred to his Department. It is not claimed that the officers would not be paid, whether on this duty or not. It is possible that the number of enlisted men, although within the whole number allowed for the Navy, might not be employed. We must admit, therefore, that the appropriations for the naval service are increased by the pay and rations for the men employed on the Coast Survey, say $92,000 per annum, or less than 15 *per cent. of the whole* expenditure for the work. This expenditure is necessary, if the work is to be done, whether administered by the Treasury or by the Navy Department.

The leading considerations which I would urge in opposition to the proposed transfer may be summed up in the following propositions:

1. The present system, perfected nearly forty years ago, has proved thoroughly efficient, economical, and satisfactory to the country. It is wise to hold fast to that which has been proved to be good.

2. It affords to the Navy all the advantages that can be legitimately claimed. It employs as many of its officers in service afloat as can be advantageously used in hydrography. The employment of a larger number, in the event of a transfer, would result in training naval officers to be geodesists, topographers, chiefs of technical bureaus, and in withdrawing their interests and habits from the naval service proper.

3. The efficiency of the service would suffer by the loss of ambition and emulation, which exist at present in a high degree, but which find no stimulus in a service where no positions of responsibility and direction are open to civil experts, however great their attainments and devotion to the public service.

Yours, respectfully,

J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

Hon. CHARLES J. FOLGER,
Secretary of the Treasury, Washington, D. C.

To the foregoing may be added that the naval officers are almost without exception well pleased with their service on the survey of the coast, although in reality more arduous than the regular routine of the naval service in time of peace. They are at all times, however, perfectly under the control of the Navy Department, and subject to being detached and ordered upon other duty. No officers above the grade of commander are attached to the survey; most of the officers are of the grades between ensign and lieutenant. They obtain a most valuable experience, which stands them in great stead on foreign stations.

The hydrographic survey along our shores is in reality not a *nautical* survey, but, properly speaking, a *trigonometrical* survey, in which the positions of the depths observed, of rocks and shoals, are determined by the observation of angles upon objects on shore, which are known by the triangulation and topography, with which the hydrography is closely co-ordinated. It cannot be separated from them without losing much of its present excellence.

It appears to me, then, that the existing relations of the Coast Survey to the Navy are working smoothly, economically, and efficiently, and that there is no reason for making any change. The plan has satisfactorily stood the test of time.

The Hydrographic Office of the Navy Department has entirely different functions from those of the Coast Survey. They consist in publishing charts of foreign coasts for the use of the Navy and our commercial marine, as also of directing surveys on foreign unsurveyed coasts by our naval vessels, when their opportunities permit. There is no duplication of work between the two services, and the distinction is clearly drawn, so that there is no clashing.

Another and principal motive for the questions propounded by the Congressional commission, is a supposed want of co-ordination of the work of the Geological Survey and the Coast and Geodetic in the interior, and a consequent duplication of work and useless expenditure. Such a state of facts does not actually exist by reason of the willing co-operation of the chiefs of the two works. Whenever the operations of the Geological Survey have touched regions to which the trigonometrical work had been extended, the director of the former work has applied for the geographical positions and distances determined, and has been promptly supplied with them. But it is obvious that here is a danger of interference and of duplication. It is necessary that the functions of the two organizations should be clearly defined, and that the mode in which their operations are to be co-ordinated should be firmly established.

To this end I am now, as I have always been, frankly in favor of the plan submitted by the Academy to Congress in 1878, according to which the Coast and Geodetic Survey should be transferred to the Interior Department, "retaining its original field of operations and assuming also the entire mensuration of the public domain," and to be known hereafter as the Coast and Interior Survey.

I see no objection on the part of the Coast and Geodetic Survey to such transfer to another civil Department, provided its present scope is preserved, and there is added to its functions the gradual execution of a trigonometrical network over the whole country, as a basis for all economic or property surveys and maps, and likewise all accurate topographical surveys.

The requisite co-operation in the plans and execution of the work of the different scientific bureaus can then be secured by the consultation of a board composed of their heads reporting to the Secretary.

Such appears to me to be a feasible plan, which, in time, may lead to the establishment of a separate governmental department.

Very respectfully yours,

J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

General M. C. MEIGS,
Chairman Committee of the National Academy of Sciences.

Letter from the Hydrographic Office.

UNITED STATES HYDROGRAPHIC OFFICE,
BUREAU OF NAVIGATION, NAVY DEPARTMENT,
Washington, September 17, 1884.

SIR: I have the honor to acknowledge the receipt of the Bureau's letter of August 16, inclosing a letter from General M. C. Meigs, U. S. A., chairman of a committee of the National Academy of Sciences, in which I am requested to give information in reference to the organization and operations of the Hydrographic Office. I have the honor to give the following as the organization of this office:

In 1846, Lieut. M. F. Maury, when in charge of the Naval Observatory and Chart Depot, which was at that time under the Bureau of Ordnance and Hydrography, began the collection of information from the logs of vessels, according to a carefully devised scheme, for the purpose of making charts to show the prevailing winds and currents, their limits and general characteristics, and, in general, all the physical features of the ocean, including its meteorology, the limits of icebergs, the feeding ground of whales, and all facts of interest and value to the maritime community. It was a long time before important results were obtained, but gradually mariners of all nations became interested, and sent their logs for examination. From the data thus gathered, Lieutenant Maury constructed his famous wind and current charts, and wrote his sailing directions. These charts and sailing directions have become known the world over, and the routes therein laid down for passages are followed to this day. It was estimated that the saving of time by the routes thus determined was equivalent to many millions of dollars annually. Two hundred thousand of the charts and twenty thousand of the sailing directions were distributed gratuitously to the masters of vessels who had contributed their logs. The continuance of this work, of invaluable benefit to the maritime interests of the world, was interrupted by the war, Maury's last publication appearing as Monograph No. 8 in May, 1861.

The Hydrographic Office was definitely established by the act of Congress approved June 21, 1866, now embodied in the Revised Statutes as follows (par. 431):

"There shall be a Hydrographic Office attached to the Bureau of Navigation in the Navy Department, for the improvement of the means for navigating safely the vessels of the Navy and of the mercantile marine, by providing, under the authority of the Secretary of the Navy, accurate and cheap nautical charts, sailing directions, navigators, and manuals of instruction for the use of all vessels of the United States, and for the benefit and use of navigators generally."

An appropriation was made at about the same time for the purchase from Messrs. E. and G. Blunt, of New York, of Bowditch's Navigator, and of a number of copper plates of charts of the several oceans, and of the waters adjacent to the coasts of the United States, but not including the coast lines. A new edition of the Navigator was published, and charts were printed from the plates, and sold to the merchant marine as they were called for. The plates of Maury's Wind and Current Charts were turned over to the Hydrographic Office, as well as those prepared under a special appropriation from the surveys made by the expeditions under Wilkes, Rodgers, Perry, and Page. To supply our ships of war with charts of every part of the world, copies were purchased of those published by the British Admiralty. A considerable number of admiralty charts have been reproduced; some in copper plate, but the greater part by photo-lithography.

As provided for in the statute establishing the Hydrographic Office, books relating to navigation, sailing directions, and other information of use to the navigator have been prepared from time to time and published; correspondence has been carried on with foreign hydrographic offices, and the information thus obtained has been republished in the form of Notices to Mariners, which have been distributed gratuitously to marine agencies and insurance companies, and to masters of vessels who have applied for them.

Efforts were resumed in 1873 to collect meteorological data from the merchant service for a new edition of Maury's Charts, and with the additional information obtained during the last twenty years, from the logs of our ships of war, a set of charts for the North Pacific has been prepared and published.

The work of the office, as now organized, is arranged in six divisions: Plate and printing; Hydrographic Office charts, British Admiralty charts, books, notices and archives, drafting and engraving, and meteorology.

PLATE AND PRINTING DIVISION.

The copper plates belonging to the office in the plate and printing division, and available for use in printing, are as follows:

Purchased from Messrs. Blunt	27
Exploring expedition plates transferred to office	112
Prepared by office, finished	165
Maury's Wind and Current Charts	24
Total	329

The number of charts printed from the above plates during the year has been 17,000.

CHART DIVISION.

The chart division has charge of all charts kept for issue to vessels, except original charts of the British Admiralty. They include charts printed from copper plates in the plate and printing division; reproductions on stone of British Admiralty charts, together with a few original French charts, and charts of the United States Coast Survey.

The number of copies on hand June 30 was as follows:

Designation of charts.	Number of charts.	Number of copies.
From copper plates:		
Blunt's charts	27	10,000
Exploring expedition charts	112	
Office charts, finished	140	
Office charts, unfinished	25	
Maury's charts	24	22,000
From stone	510	83,000
	838	115,000
Deducting the wind and current charts	24	22,000
Total sailing charts	814	93,000

The number of charts issued during the year has been as follows:

To ships of war	5,941
To merchant vessels transmitting meteorological journals	1,570
To home correspondents and libraries	574
To foreign hydrographic offices (exchanges)	537
To agents, for sale	8,857
To navy-yards and Government offices	7,886
Total	25,365

ADMIRALTY CHART DIVISION.

The hydrographic office connected with the British Admiralty has published a series of charts numbering about 3,000, and representing bodies of water in all parts of the world. From 75 to 100 charts are issued, and about double the number receive important corrections annually. The series forms the most complete collection in existence, and the navigators of all countries, whether naval or mercantile, must rely primarily upon this office for charts. Of these publications, the admiralty chart division of the Hydrographic Office keeps at all times a supply. At present, the aggregate number of copies on hand is 16,000, representing 2,300 charts. Every new chart, and every chart having important corrections, is received from the British Admiralty at the Hydrographic Office as soon as issued.

DIVISION OF BOOKS.

In the division of books, there are 20,000 copies of the publications of this office, of the United States Coast and Geodetic Survey, and of the Light-House Board, and others purchased abroad for the use of our naval vessels. The first only are kept for sale. Several copies of each publication are always kept corrected to the latest date.

NOTICE AND ARCHIVE DIVISION.

The division of notices and archives contains single copies of 7,000 American and foreign charts, kept for reference. In this division is also filed all nautical information from whatever source received. During the year, there have been received from thirty foreign hydrographic offices, and marine and port departments, 2,400 printed notices. The notices in foreign languages, including Chinese and Japanese, as well as those of nearly every country in Europe, have been translated by naval officers attached to the division. The information obtained from the notices has been republished in notices to mariners, indicating changes of lights and buoys, and in hydrographic notices indicating changes in hydrography.

METEOROLOGICAL DIVISION.

The province of the meteorological division is to furnish blank meteorological journals to the masters of merchant vessels who are willing to post them, the masters receiving in return a set of charts covering the route to be traversed. The data obtained from these journals and from the log-books of ships of war are condensed for use in the construction of new editions of Maury's Wind and Current Charts. From this division is issued a monthly pilot chart, which shows graphically the possible limits of the Gulf Stream, icebergs, the best track for steamers, reported rocks, shoals, and other marine dangers, the establishment of new lights, and changes in position of buoys, &c.

BRANCH OFFICES.

In order to extend the full benefit of the co-operation of this office with all foreign offices to the merchant marine, branch offices are located in Boston, New York, Philadelphia, Baltimore, New Orleans, and San Francisco. These branches are in charge of officers detailed from the main office. Each branch is supplied with charts covering the navigable waters of the globe, nautical works, light lists, and sailing directions, all corrected to date. The plan has the double advantage of placing within easy reach of masters of vessels all the information contained in the Hydrographic Office, and of enabling the office to obtain with greater fullness, accuracy, and dispatch all the information brought to those ports by incoming navigators as the fruit of their own experience. The number of vessels boarded during the last six months foots up 5,000. Logs have been examined, and barometers and charts corrected to date.

For a thorough understanding of interior details, and what the office is accomplishing for the merchant marine and the cause of science, the office is at all times open to the personal inspection of those interested.

Very respectfully,

J. R. BARTLETT, U. S. N.,
Commander and Hydrographer.

Commodore J. G. WALKER, U. S. N.,
Chief of the Bureau of Navigation.

Letters from Prof. J. D. Dana.

NEW HAVEN, *September* 12, 1884.

DEAR SIR: On the urgent request of Prof. W. P. Trowbridge, I take the liberty of writing you briefly with regard to the kind of maps which appear to be needed for geological field work.

I would remark, in the first place, that when in the field I have been always troubled by the want of a trustworthy map. I have worked much in the bordering parts of Connecticut, New York, and Massachusetts, and I have found it impossible to unite the larger published maps of these several States into a common map, or the maps of Connecticut towns into a State map, without a degree of manipulation, of shifting of rivers and roads, that was shocking to one's scientific and moral sensibilities. Such facts are well known among State and town surveyors. There is obviously no doubt as to the great need of a geodetic and topographical survey that will result in the production of accurate maps.

The maps should be large enough in scale for ordinary geological purposes, and accurate enough to admit of enlargement without introducing thereby serious topographical errors. A scale of 2 inches to the mile I think would be sufficient for ordinary work.

The accuracy of the maps should be the highest that is attainable. The geologist needs to lay down the limits of formations, to determine and record bearings, to make records of the courses of structure-lines, of feature-lines, and of all lines of dynamical import. He finds often in feature-lines an indication of broad facts as to structural relations and stratigraphical details, as to the limits or range of a rock formation, as to the characters of rocks, and the changes that have taken place over them. The surface over the most of the continent is so largely under soil that he has often to rely on facts from widely distant points, and a knowledge of relative heights or courses is sought in order to solve the problems that present themselves.

Given a map on which *the roads* are accurately laid down, even to each turn and the position of *each house,* and the geologist, whenever at work over the area it represents, has a base to measure from for each locality of interest or rock limit, and he feels sure that his work may be correctly registered and will not need to be done over again because maps will some time be better.

Give him *contour-lines* that are exact, and he has starting-points that can be trusted for detailed measurements as to new levels, and a means also of finding his position in a region.

The free-hand contour-lines much used of late are of no value to the careful geologist. They may give the general shape of the surface sufficiently well to satisfy the geographer, but they are grossly misleading if used for any other purpose.

Under the United States Coast and Geodetic Survey, a careful survey was made, a few years since, of the region about New Haven, Conn., including about 40 square miles. It has contour-lines for every *twenty* feet. I have found it even a source of geological revelations. Outcrops of trap occur in distant hills; with the map in hand, the outcrops are seen to fall into line, and are proved to be parts of a common dike. Bowl-like depressions of the surface are scattered about; on the map, they are found to be systematically arranged with reference to other features and depressions. Ridges, valleys, and plains make up the surface; on the map, a nearly common direction is found for the sandstone ridges and intervening valleys, and this direction corresponds with that of the glacier movement in the Glacial era. And so I might go on with other details.

It thus appears to me that, even if geology alone is considered, there cannot be too great accuracy in the topographical survey of the country; and that no contour-lines should be drawn on a map that are not strictly accurate up to the limit of surveying capabilities; that, until such accuracy can be attained, levels and form should be indicated only by ordinary lines of shading and records of actually measured heights; and, of the latter, the more the better.

I beg you will excuse my addressing you so freely, and believe me, with highest esteem, very truly yours,

JAMES D. DANA.

General M. C. MEIGS.

NEW HAVEN, *September* 18, 1884.

DEAR SIR: I have the pleasure of acknowledging the receipt of your letters of the 16th and 17th.

As to the degree of accuracy required in maps for geological investigators, I may have expressed myself a little too strongly, but I think only a little. I was prompted by my own difficulties and sense of need while in the field. I have long felt that what the field geologist needs most or first is maps on which all the roads, wood-roads, rivers, and brooks are laid down with accuracy, and, besides this, the positions also of houses, churches, bridges (even the smallest), &c. Each house, or turn in the road, or bridge, or road-crossing serves as a base for fixing localities and lines, and is almost the only resource at hand, and if the positions are inaccurate so is the field work. If roads on a map are too near together, or too far apart, or too far from a *river,* or bends in a river are out of place, the belt of limestone or other rock which the geologist attempts to plot takes false or distorted shapes, or has too great or too little width, leading to false conclusions and discordances different ways.

To a map that is correct in its geographical lines, the addition of the topography and true levels is of great importance, and these levels should be given over the plains and valleys as well as for mountain regions. I should make no use of any contour-lines that were not a result throughout of direct measurement or of the best plane-table work. Were a geologist attempting to lay down the high terrace along a river valley, correct levels for points along the bottom of the valley would be of great value, while free-hand contour-lines over the region could not be trusted. I may add that where contour-lines are correctly put in it is not often easy to find the exact points over which they pass, so as to be able to use the level at any point as a base for special measurements (I speak from attempts to use the New Haven map); and hence I think it desirable that where contour-lines cross roads, the distance of this crossing from the next corner or turn in the road should in some way be noted on the map.

Of course roads and rivers cannot be correctly mapped without first a primary and secondary triangulation.

The size of map which I mentioned, 2 inches to the mile, is insufficient for much detailed geological work. This size is one which ought to come within the probable limits of appropriations. A smaller size is, in my opinion, quite inadequate for anything more than a rough reconnaissance. This is especially true with regard to regions like New England and the other metamorphic and much disturbed portions of the continent. I was yesterday where a map of 6 inches to the mile, or larger, would be required to plot intelligibly the distribution of the limestone and schist; but these are exceptional cases, and there should be an exceptional provision for them.

Very truly yours,

JAMES D. DANA.

General MEIGS.

APPENDIX E.

REPORT ON CUSTOMS DUTY ON PHILOSOPHICAL AND SCIENTIFIC APPARATUS.

[CORRESPONDENCE.]

YALE COLLEGE,
New Haven, Conn., December 8, 1884.

SIR: I have the honor to transmit to you herewith a report on the customs duty on philosophical and scientific apparatus, made by a committee of the National Academy of Sciences, in compliance with a request of your predecessor, dated September 13, 1884.

I return herewith, as requested, the inclosures sent with that communication.

Very truly yours,

O. C. MARSH,
President of the National Academy of Sciences.

The Hon. SECRETARY OF THE TREASURY.

TREASURY DEPARTMENT, OFFICE OF THE SECRETARY,
Washington, D. C., September 13, 1884.

SIR: I have the honor to transmit herewith a copy of a letter from Mr. E. B. Moore, appraiser of customs at Philadelphia, dated the 21st ultimo, in which he states that great difficulty is experienced in determining what instruments and other articles are entitled to classification for duty as "philosophical apparatus and instruments," under the tariff act of March 3, 1883, a copy of which, duly marked, is herewith inclosed, and suggests that the subject be referred to the Smithsonian Institution, with a request to prepare a list of such apparatus and instruments, for the use of customs officers in the premises.

In accordance with such suggestion, Professor Baird was requested to furnish the desired list, but the Department is in receipt of a communication from him, dated the 9th instant, in which he recommends that the matter be referred to you, with the request that you appoint a committee of the Academy for the purpose of reporting a list comprising the different articles which properly come within the scope of the said statutory provision.

A list of certain articles lately imported into Philadelphia, and claimed by the importers to be philosophical instruments and apparatus, and four printed catalogues, are also transmitted, and the Department will feel obliged if you will comply with the recommendation of Professor Baird, and furnish the said list.

A return of the five inclosures last mentioned is respectfully requested.

Very respectfully,

H. F. FRENCH,
Acting Secretary.

Prof. O. C. MARSH,
President National Academy of Sciences.

THE NATIONAL ACADEMY OF SCIENCES,
Washington, December 2, 1884.

SIR: I have the honor to transmit to you herewith the report of the committee appointed to consider the matter submitted to you by the honorable Secretary of the Treasury in regard to customs duties on philosophical and scientific apparatus.

Very respectfully, your obedient servant,

GEO. J. BRUSH,
Chairman.

Prof. O. C. MARSH,
President National Academy of Sciences.

REPORT.

The committee of the National Academy of Sciences appointed, in accordance with the request of the Secretary of the Treasury contained in his letter dated September 13, 1884, to consider the subject of customs duty on philosophical and scientific apparatus, submit the following:

The letter of the United States appraiser addressed to the collector of the port of Philadelphia, and inclosed to us, seems to imply that a distinction exists between what may be regarded as scientific instruments and those that are known to scholars as philosophical. Your committee think that it is impossible to draw any such distinction, and, moreover, they do not find any separate reference to scientific instruments as distinct from philosophical in the tariff bill approved March 3, 1883. The only references to such instruments as forming a separate clause are as follows:

Schedule N, section 475, "Sundries," contains the clause, "Philosophical apparatus and instruments, 35 per cent. ad valorem."

The free list (section 759, page 58) contains the clause, "Philosophical and scientific apparatus, instruments, and preparations * * * specially imported in good faith for the use of any society or institution incorporated for religious, philosophical, educational, scientific, or literary purposes, or for encouragement of the fine arts, not intended for sale."

The meaning, objects, and limitations of these clauses do not seem to your committee to offer any difficulty. Although the term "philosophical" as applied to instruments has long ceased to be employed in scientific language, it has a well defined signification in ordinary use. It has come down from a time when nearly all our knowledge of inanimate nature was comprehended under the general term "natural philosophy," and the instruments and apparatus necessary for acquiring and illustrating that knowledge were termed "philosophical." The obvious intent of Congress in specially designating philosophical instruments was to cover the case of institutions and individuals who might import the instruments and apparatus for the purpose of improving natural knowledge. It therefore appears to us that the terms "philosophical apparatus and instruments" in both clauses quoted should be held to cover all such instruments and apparatus imported for this purpose.

It does not appear to your committee that the addition of the word "scientific" in the last clause of the law quoted comprehends any objects other than those which may be included under the term "philosophical" as hereinbefore defined. We regard the addition of this word as merely intended to render the meaning of Congress more explicit.

The letter of the honorable Secretary of the Treasury embodies a request that the Academy shall prepare a list of instruments and apparatus which, in its opinion, should belong in the class philosophical. Recognizing the insufficiency of any general definition to enable the collectors of customs to decide to what class a given object belongs, your committee has given much attention to the question of preparing the required list. They have not, however, found it possible to do this in a way which would be at all satisfactory. The difficulties are two in number: Firstly, an instrument is philosophical, not in consequence of its special construction or function, but in consequence of the uses to which it is to be put, and many instruments may be put both to uses which are philosophical and to uses which are purely industrial or commercial. Secondly, the number of different kinds of philosophical apparatus is so great, and new kinds are so constantly added, that an exhaustive enumeration is impracticable.

Respectfully submitted.

GEO. J. BRUSH, *Chairman.*
WOLCOTT GIBBS,
SAMUEL H. SCUDDER,
SIMON NEWCOMB,
GEORGE F. BARKER,
Committee.

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REPORT

OF THE

NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1885.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

REPORT

OF THE

NATIONAL ACADEMY OF SCIENCES

FOR

THE YEAR 1885.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

LETTER OF TRANSMITTAL.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., January 20, 1886.

SIR: In conformity with the requirements of the act of incorporation, approved March 3, 1863, I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year.

Very respectfully, your obedient servant,

O. C. MARSH,
President of the National Academy of Sciences.

The PRESIDENT OF THE SENATE.

REPORT
OF
THE NATIONAL ACADEMY OF SCIENCES.

The National Academy of Sciences was established by act of Congress, in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

The object of the Academy is to advance science, and especially to investigate, examine, experiment, and report on any subject of science or art, whenever called upon by any Department of the Government.

The Academy contains at present about one hundred members, and these have all been selected for their original researches in science. They represent within their ranks nearly every department of knowledge, and their services, in accordance with the charter of the Academy, are always at the disposal of the Government, without compensation.

SESSIONS OF THE NATIONAL ACADEMY.

During the past year, the Academy has held three sessions. The first was the regular annual meeting, held in Washington, D. C., April 21 to 24, 1885; the second was a scientific session, in Albany, N. Y., November 10 to 13, 1885; and the third was a special session, in Albany, November 11 and 13, 1885.

STATED SESSION.

HELD IN WASHINGTON CITY, APRIL 21 TO 24, 1885.

The Washington session was held in the National Museum, the president, Prof. O. C. Marsh, presiding.

The following members were present during the session:

Abbe.
Abbot.
Allen.
Baird.
Barker.
Bell.
Billings.
Brooks.
Brush.
Coffin.
Comstock.
Cope.
Coues.
Dutton.
Ferrel.
Gilbert.
Gill.
Hall, A.
Hilgard, J. E.
Hill, G. W.
Hunt.
Lyman.
Marsh.
Mitchell, H.
Morse.
Newcomb.
Packard.
Powell.
Pumpelly.
Remsen.
Rowland.
Schott.
Scudder.
Sellers.
Wright.
Young.

Mr. A. N. Skinner was present by invitation of the Academy.

The president, in a brief address to the Academy, reviewed the business of the past year, and specially commented upon the relations of the Academy to the other Departments of the Government.

At this session, the following papers were read:

1. Billings, J. S., and Matthews, W.—Methods of Measuring the Cubic Capacity of Crania. Discussed by Messrs. Gill and Billings.
2. Scudder, S. H.—On Winged Insects from a Paleontological Point of View. Discussed by Messrs. Cope and Gill.
3. Packard, A. S.—On the Syncaridæ, a Hitherto Undescribed Group of Extinct Malacostracous Crustacea. Read by Mr. Gill.
4. Packard, A. S.—On the Anthracaridæ, a Family of Carboniferous Macrurous Decapod Crustacea, Allied to the Eryonidæ. Remarks by Mr. Gill.
5. Hunt, T. Sterry.—On the Classification of Natural Silicates. Discussed by Messrs. Remsen and Hunt.
6. Comstock, C. B.—On the Ratio of the Metre to the Yard.
7. Loomis, Elias.—On the Cause of the Progressive Movement of Areas of Low Pressure. Read by Mr. Abbe.
8. Hilgard, J. E., and Lindenkohl, A.—On the Submarine Geology of the Approaches to New York.
9. Gill, Theodore.—The Orders of Fishes. Discussed by Messrs. Cope and Gill.
10. Powell, J. W.—On the Organization of the Tribe.
11. Hill, G. W.—On Certain Lunar Inequalities Due to the Action of Jupiter, and Discovered by Mr. E. Neison.
12. Young, C. A.—On Some Recent Observations upon the Rotation and Surface Markings of Jupiter.
13. Cope, E. D.—On the Pretertiary Vertebrata of Brazil.
14. Rowland, H. A.—On the Value of the Ohm.
15. Packard, A. S.—On the Gampsonychidæ, an Undescribed Family of Fossil Schizopod Crustacea.
16. Cope, E. D.—On the Phylogeny of the Placental Mammalia. Discussed by Messrs. Morse, Gill, and Cope.
17. Skinner, A. N. (by invitation of the Academy).—On the Total Solar Eclipse of August 28, 1866. Discussed by Messrs. Young and Coffin.
18. Remsen, Ira.—Chemical Action in a Magnetic Field. Discussed by Messrs. Newcomb, Barker, Bell, Young, and Wright.
19. Bell, A. Graham.—On the Measurement of Hearing-power. Remarks by Mr. Scudder.
20. Gill, Theodore, and Ryder, John A.—On the Evolution and Homologies of the Flukes of Cetaceans and Sirenians.
21. Bell, A. Graham, and Torre, F. Della.—On the Possibility of Obtaining Echoes from Ships and Icebergs in a Fog.
22. Genth, F. A., and Rath Gerhard von.—On the Vanadium Minerals; Vanadinite, Endlichite, and Descloizite, and on Iodyrite, from the Sierra Grande Mine, Lake Valley, New Mexico.

BIOGRAPHICAL MEMOIRS.

The following biographical notices were read:

Of Dr. J. J. Woodward, by Dr. J. S. Billings.

Of General A. A. Humphreys, by General H. L. Abbot.

Of Dr. William Stimpson, by Prof. Theodore Gill. (Read by title.)

ELECTIONS.

The following members were selected for the council for the ensuing year: Messrs. S. F. Baird, W. Gibbs, J. E. Hilgard, M. C. Meigs, S. H. Scudder, and C. A. Young.

NEW MEMBERS.

The following new members were elected: Dr. Arnold Hague, Prof. Edward S. Holden, Prof. Henry Mitchell, Prof. F. W. Putnam, and Prof. William A. Rogers.

TREASURER'S REPORT.

The treasurer presented the following report, which had been examined by the auditing committee, Messrs. Remsen, G. W. Hill, and Ferrel, and approved:

1. *General account, April* 14, 1884, *to April* 20, 1885.

RECEIPTS.

Cash balance from last year		$217 39
Dues collected from members		420 00
Interest on District of Columbia 3.65 bond		27 37
Sale of $500 District of Columbia 3.65 bond		555 00
Total receipts		1,219 76

EXPENDITURES.

Printing memoirs and proceedings	$314 81	
Printing circulars	17 70	
Expenses of secretary and treasurer	94 41	
Expenses of recording secretary and copyist	103 40	
Rent of room to May 1	8 00	
Box for treasurer	10 50	
Drawings for eclipse report	90 08	
Expenses of April and November meetings	172 40	
Expenses of glucose committee disallowed	2 50	
Expenses of committee on Government surveys	239 90	
Total expenditures		1,053 70
Cash balance on hand April 20, 1885		166 06
Dues from members		65 00
Claim on United States Government		239 90
$500 District of Columbia 3.65 bond, market value		565 00
Total assets		1,035 96
Decrease of District of Columbia 3.65 bond		500 00

2. *The Bache Trust Fund.*

RECEIPTS.

Cash balance from last year	$3,417 54
Interest on securities, investments	2,144 48
Interest on District of Columbia 3.65 bond, income	200 75
Sale of $2,000 District of Columbia 3.65 bond	2,220 00
Total receipts	7,982 77

EXPENDITURES.

Orders of board of direction	$3,575 00	
Taxes and expenses on Missouri land	7 85	
Purchase of $2,000 District of Columbia 3.65 bond	2,300 00	
Total expenditures		$5,882 85
Cash balance April 20, 1885		2,099 92
$4,500 District of Columbia 3.65 bond, market value		5,085 00
Total assets		7,184 92
Outstanding order of board of direction		2,500 00
Excess of assets		4,684 92

3. *The Watson Fund.*

RECEIPTS.

Cash balance from last year		$1,292 75
Interest and dividends on investments		782 00
Total receipts		2,074 75

EXPENDITURES.

Model and cost of Watson medal	$25 00	
Drawings for eclipse report	100 00	
Purchase of $850 United States 4 per cent. bond	1,049 75	
Total expenditures		1,174 75
Cash balance on hand April 20, 1885		900 00
Increase of uninvested fund		850 00

4. *The Henry Draper Medal Fund.*

RECEIPTS.

Cash balance from last year	$200 00
Interest on investments	200 00
Cash balance on hand April 20, 1885	400 00

5. *The J. Lawrence Smith Fund.*

RECEIPTS.

Cash received from Mrs. Smith	$8,000 00
Interest on investments	243 00
Total receipts	8,243 00

EXPENDITURES.

Purchase of $7,200 United States 4½ per cent. bond	8,073 00
Cash balance on hand April 20, 1885	170 00
Investment in United States 4½ per cent. bond	720 00

J. H. C. COFFIN,
Treasurer.

The following report of the committee to examine securities held by the Academy was read and approved:

WASHINGTON, D. C., *April* 21, 1885.

The committee, Messrs. Bell and Billings, appointed to examine the securities in the hands of the treasurer, report that they have examined the said securities, and find that they are as follows:

1. *General Fund.*

District of Columbia, 3.65 per cent	$500 00

2. *Bache Trust Fund.*

United States loan, 4½ per cent	$42,100 00
United States loan, 4 per cent	3,850 00
City of Davenport loan, 6 per cent	1,000 00
City of Philadelphia loan, 6 per cent	600 00
	47,550 00

Also, a deed of 160 acres of Missouri lands not yet recorded in the name of the Academy, and four medals presented to the late A. D. Bache, and received from his estate.

3. *Income of the Bache Fund.*

District of Columbia, 3.65 per cent	$4,500 00

The registered securities stand in the name of the National Academy of Sciences, without specifying the fund to which they belong. The securities have been classified as above, in accordance with information derived from the treasurer.

4. *Joseph Henry Fund.*

An agreement with the Pennsylvania Company for insurance on lives, and granting annuities, as to the final disposition of the Joseph Henry fund of	$40,000 00

5. *Henry Draper Medal Fund.*

United States loan, 4 per cent	$5,000 00

Also, the deed of trust of Mary Anna Palmer Draper to the National Academy of Sciences.

6. *Watson Trust Fund.*

United States loan, 4½ per cent	$6,200 00
United States loan, 4 per cent	850 00
Certificates for 134 shares of capital stock of the Michigan Mutual Life Insurance Company	6,700 00
	13,750 00

7. *J. Lawrence Smith Fund.*

United States loan, 4½ per cent	$7,200 00

Also, a deed of trust of Sarah Julia Smith to the National Academy of Sciences.

DEATH OF MEMBERS.

The president announced the death, since the last meeting, of Prof. Benjamin Silliman.

Prof. James D. Dana was appointed to prepare a biographical notice.

RESOLUTIONS.

On recommendation of the council, the Academy adopted the following resolutions:

Resolved, That the assessment for the ensuing year be $5.

Resolved, That the home secretary be appointed custodian of the property ot the Academy, and be authorized to receipt therefor.

Resolved, That J. H. C. Coffin, treasurer of the National Academy of Sciences, be and is hereby authorized and empowered to assign any and all 3.65 registered bonds of the District of Columbia, now standing in the name of the Academy, and to appoint one or more attorneys for that purpose.

Resolved, That the treasurer be authorized to defray the expenses of the present session on certification by the chairman of the committee of arrangements.

Resolved, That the treasurer be authorized to reserve from the income of the Draper fund, $65 each year, and such further sum as the committee on that fund may authorize, to be invested from time to time until the invested fund is increased to $6,000, the sum intrusted to the Academy by Mrs. Draper.

Resolved, That the treasurer be authorized to reserve from the income of the J. Lawrence Smith fund, $133 each year, to be invested from time to time until the invested fund is increased to $8,000, the amount intrusted to the Academy by Mrs. Smith.

Resolved, That the National Academy of Sciences gratefully acknowledges the receipt of a fund of $8,000, presented in trust by Mrs. Sarah Julia Smith, to promote the study of meteoric bodies; that the Academy adopts and confirms the action of its president in accepting such trust, and promises the faithful execution of the same.

Resolved, That the Academy appreciates the confidence reposed by the donor in selecting it as the trustee for executing her purpose, and her further liberality in providing dies for a suitable medal.

Resolved, That a committee of five members be appointed by the president, to recommend to the Academy such measures as may be necessary to the proper execution of the trust.

Resolved, That the said committee be charged with the duty of preparing an expression of appreciation by the Academy of the munificence of Mrs. Smith, and of having such expression suitably engrossed and signed by the proper officers, for transmission to the donor.

COMMITTEE ON THE SMITH FUND.

The president appointed, as permanent committee on the Smith fund, the following members:

Gibbs, Wolcott, *Chairman.*
Hall, A.
Brush, G. J.
Pumpelly, R.
Rutherfurd, L. M.

SMITH DEED OF TRUST.

The secretary then read the deed of gift of Mrs. Smith, as follows:

Deed of trust from Mrs. Sarah Julia Smith, of Louisville, Ky., to the National Academy of Sciences.

Know all men by these presents, that I, Sarah Julia Smith, of the city of Louisville, and county of Jefferson, State of Kentucky, in consideration of the premises, and of the acceptance of the within trust by the National Academy of Sciences, and also in consideration of divers other good and valuable considerations, I, the said Sarah Julia Smith hereunto moving, have given, granted, assigned, transferred, and set over, and by these presents do give, grant, assign, transfer, and set over unto the said National Academy of Sciences, and to their successors forever, a certain fund or sum of $8,000, with the interest and income thereof, to have and to hold the same in trust nevertheless, upon the special trusts, and for the uses and purposes following, to wit:

First. In trust, to invest and to reinvest the said sum of $8,000, and to keep the same invested in good and safe securities, or in such other manner as shall be, in their opinion, best for the preservation and maintenance of such fund.

Second. In trust, to use the interest and income thereof for the purpose of striking a gold medal, which shall be called the "Lawrence Smith Medal," shall be of the value of $200 in gold, and shall be struck in a die, to be selected and presented to the said National Academy of Sciences by me, the said Sarah Julia Smith. And the said medal shall be awarded and presented from time to time, by the said National Academy of Sciences, to any person in the United States of America or elsewhere, who shall make an original investigation of meteoric bodies, the results of which shall be made known to the public, such results being in the opinion of the said National Academy of Sciences of sufficient importance and benefit to science to merit such recognition; provided, however, that said medal shall not be presented or awarded more frequently than once in two years, and provided, also, that the investigation for which it is awarded, or the completed publication thereof, shall have been made since the time of the last preceding award and presentation of said medal.

Third. In trust, that if investigations of equal importance shall be made in regard to meteoric bodies at or about the same time in the United States of America, and also in some other part of the world, each of which investigations might, in the opinion of the said Academy, entitle the investigator to be considered as a competitor for said medal, preference shall be given in the awarding thereof to investigations made by a citizen of the said United States of America.

Fourth. In trust, that if the said die shall at any time be lost, destroyed, broken, or in any manner rendered unfit for the purpose of striking the said medal, a new die shall be procured exactly similar to the one so selected and presented as aforesaid, and shall be paid for out of the interest and income of the said fund; and such sum or sums of money as shall at any time or times be necessary for the care, custody, and protection of the said die or of the said fund hereby given shall also be taken from and out of the interest and income of the said fund whenever the same shall be deemed necessary by the said National Academy of Sciences.

Fifth. In trust, that if at any time or times the interest and income of said trust fund of $8,000 shall exceed the amount necessary for the striking of said medal and the care of the said die and of the fund, such surplus over and above the sum or sums so required for the purposes of the trust, as hereinbefore recited and set forth, shall be used in such manner as shall be selected by the National Academy of Sciences in aid of investigations of meteoric bodies, to be made and carried on by a citizen or citizens of the United States of America.

And the said National Academy of Sciences doth signify its acceptance of the said fund of $8,000, and doth engage to hold and manage the same upon the trusts and for the uses and purposes herein mentioned and set forth.

In witness whereof, I, the said Sarah Julia Smith, have hereunto set my hand and seal, and the said National Academy of Sciences hath hereunto caused its corporate seal to be affixed, and these presents to be subscribed by its president, this 6th day of May, in the year 1884.

SARAH JULIA SMITH. [SEAL.]

Sealed and delivered in presence of—
ANNIE C. NORTON.
J. H. CAPERTON.
[SEAL.]

O. C. MARSH,
President of the National Academy of Sciences.

Witnesses to signature:
GEO. J. BRUSH.
E. S. DANA.

LETTER TO MRS. SMITH.

Mrs. SAR JUSMITH:

MADAM: It is our duty as a committee of the National Academy of Sciences to tender to you the thanks of the Academy for the munificent donation which you have intrusted to it. With the most sincere appreciation of the spirit which dictated your gift, and with profound respect and sympathy, we now discharge the duty which has devolved upon us.

The noble and unselfish life of our lamented fellow-member, Dr. J. Lawrence Smith, was devoted to science; and of the work which he did, and which confers eternal honor upon his name, no part is more deeply interesting or more permanently valuable than his researches on the chemical constitution of meteorites, researches in which he first established in these bodies the existence of hydrocarbon. His beautiful collection has become the property of one of our most prominent colleges. His name and fame are national possessions. The income of the fund which you have intrusted to the Academy, worthily bestowed, cannot fail to assist materially in extending our knowledge of meteoric phenomena.

The Academy accepts the trust, which honors the giver, which recalls the life-long services of one of its most honored members, and which promises to extend the boundaries of the science to which he was devoted. We tender to you, madam, in the name of the Academy, our grateful acknowledgments.

WOLCOTT GIBBS, *Chairman.*
G. J. BRUSH,
A. HALL,
R. PUMPELLY,
L. M. RUTHERFURD,
Committee.

JULY 27, 1885.

CONSTITUTIONAL AMENDMENTS.

The Academy, in committee of the whole, adopted the following amendments, viz:

In ARTICLE III, section 1: In place of the words "may be held" read "shall hold."

In ARTICLE IV, sections 4 and 5: In place of the words "at the next stated session held in Washington" shall be substituted the words "at the next stated session."

REPORTS OF COMMITTEES.

The committee on ways and means to provide a fund for the Academy reported progress.

The committee on reserving public lands on and near Mount Whitney, California, for scientific purposes; the committee to co-operate with the National Board of Health; the committee on the publications of the Academy; and the committee on the organization of the national surveys and Signal Service were continued.

The committee to report on the triangulation to connect the Atlantic and Pacific coasts, and the committee on customs duty on philosophical and scientific apparatus were discharged.

Mr. Coffin, on the part of the board of trustees of the Watson fund, reported that since the session of the Academy in April, 1884, in accordance with resolutions then passed, the invested fund has been increased to $13,750, the sum received from the bequest of Professor Watson, and progress has been made in procuring a model of the proposed Watson medal, and the work on the small planets, under the direction of Mr. Newcomb, has been commenced, but no money has yet been drawn from the treasury for that purpose.

The committee on the Henry Draper medal reported that it has had before it the claims of various investigators working in the field of astronomical physics, and has considered fully their claims to the distinction implied in the award of this medal by the Academy.

That as a result of its investigations, the committee recommends to the Academy the award of the Henry Draper medal to our fellow-member, Prof. S. P. Langley, for his researches and discoveries in relation to solar radiation. This recommendation was adopted.

INVITATIONS.

It was announced that the President of the United States would hold a reception on the evening of April 21, and members of the Academy were especially invited to be present.

A letter was received from Commander and Mrs. Brown, inviting the members of the Academy to visit the Naval Observatory on the afternoon of April 24.

Also, an invitation from Prof. A. Graham Bell to attend a reception on Thursday, the 23d.

Members of the Academy and their friends were invited to attend the meeting of the Anthropological Society, to be held Tuesday, the 21st.

A communication was received from the Cosmos Club, tendering to members of the Academy the use of their club house for the period of twenty days.

NOMINATIONS.

Fourteen nominations for membership were made, to be voted on at the next stated session.

The Academy adjourned April 24, 1885.

SCIENTIFIC SESSION.

HELD AT ALBANY, N. Y., NOVEMBER 10 TO 13, 1885.

A scientific session, for the reading of papers only, having been called by the council, as announced at the April session, the Academy convened in the assembly parlor of the capitol at Albany, N. Y., on November 10, 1884.

The president, Prof. O. C. Marsh, presided.

The following members were present during the session:

Bell.
Hall, A.
Hall, J.
Marsh.
Morse.
Morton.
Newberry.
Newcomb.
Newton, H. A.
Peters.
Pickering.
Powell.
Pumpelly.
Putnam.
Scudder.
Sellers.
Young.

The following gentlemen were invited to attend the meetings and to take part in the scientific proceedings: Prof. Lewis Boss, Prof. W. B. Dwight, Prof. Charles H. Peck, Prof. C. K. Weed, Mr. Joseph A. Lintner, Prof. T. H. Safford, Mr. O. T. Sherman, and Dr. Otto Meyer.

At this meeting, the following papers were read:

1. Packard, A. S.—On the Carboniferous Merostomatous Fauna of America. Read by Mr. Scudder.
2. Billings, J. S.—On a New Form of Craniaphore for Taking Composite Photographs. Read by Mr. Bell.
3. Hall, James.—Remarks upon the International Geological Congress at Berlin, with a brief historical notice of the origin of the congress.
4. Young, C. A.—On the New Star in the Nebula of Andromeda.
5. Pickering, E. C.—On Stellar Photography.
6. Langley, S. P.—On Obscure Heat.
7. Peters, C. H. F.—On Certain Stars Observed by Flamsteed and Supposed to have Disappeared.
8. Dwight, Wm. B. (by invitation of the Academy).—Primordial Rocks among the Wappinger Valley Limestones, near Poughkeepsie, N. Y.
9. Sherman, O. T. (by invitation of the Academy).—On New Lines in the Spectra of Certain Stars.
10. Hall, James.—Notes on Some Points in the Geology of the Mohawk Valley.
11. Safford, T. H. (by invitation of the Academy).—On the Formation of a Polar Catalogue of Stars.
12. Peters, C. H. F.—On the Errors of Star Catalogues.
13. Newcomb, Simon.—When shall the Astronomical Day Begin?
14. Meyer, Otto (by invitation of the Academy).—On a Section through the Southern Tertiaries.
15. Powell, J. W.—Remarks on the Stone Ruins of the Colorado and the Rio Grande.
16. Bell, A. G.—Preliminary Report on the Investigation Relating to Hereditary Deafness.
17. Cope, E. D.—On Two New Forms of Polyodont and Gonorhynchid Fishes from the Eocene of the Rocky Mountains. Read by title by Mr. Morse.
18. Lintner, J. A. (by invitation of the Academy).—On Recent Progress in Economic Entomology.

19. PECK, CHARLES H. (by invitation of the Academy).—The New York State Herbarium.
20. NEWBERRY, J. S.—On Recent Discoveries of Gigantic Placoderm Fishes in the Devonian Rocks of Ohio.
21. HALL, JAMES.—Remarks upon the Lamellibranchiata Fauna of the Devonian Rocks of the State of New York, and the Results of Investigations made for the Palæontology of the State.
22. NEWBERRY, J. S.—On the Flora of the Cretaceous Clays of New Jersey.

The scientific session closed November 13, 1885.

SPECIAL SESSION.

HELD AT ALBANY, N. Y., NOVEMBER 11 and 13, 1885.

A special session of the Academy having been called by the council, in accordance with Article III, section 1, of the constitution, the Academy convened in the assembly parlor of the capitol, November 11, 1885, the president, Prof. O. C. Marsh, presiding.

The president made a statement concerning the request of the Secretary of the Navy for a committee of the Academy to consider and report upon certain questions relating to the Naval Observatory at Washington, and stated that he had appointed the following committee, who now had the matter under consideration:

Barnard, F. A. P., *Chairman.*
Bell, A. Graham.
Dana, J. D.
Langley, S. P.
Lyman, Theodore.
Pickering, E. C.
Young, C. A.

The president also made a statement of the business and publications of the Academy during the past summer, and requested members who have memoirs to print to send the manuscript to him before December 1, 1885.

The meeting then adjourned to meet November 13, at the close of the scientific session.

ADJOURNED MEETING.

HELD NOVEMBER 13, 1885.

The adjourned business meeting of the Academy met at 1 o'clock p. m.

The president was authorized to present his annual report to Congress, and to include the proceedings of the present scientific session.

DEATH OF FOREIGN ASSOCIATE.

The president announced the death of Henry Milne-Edwards, foreign associate of the Academy.

RESOLUTIONS.

The following resolutions were adopted:

Resolved, That the thanks of the Academy be tendered to the trustees and director of the State Museum of Natural History; to the trustees and faculty of the Albany Medical College; to the trustees and director of the Dudley Observatory, and to the officers and members of the Albany Institute, for the courteous and considerate attention shown by them to the Academy, and for their efforts to promote the success of the present meeting.

Resolved, That the thanks of the Academy be tendered to the trustees of public buildings of the State of New York for the use of the commodious rooms in which the Academy has held its sessions.

The special meeting then adjourned.

Respectfully submitted.

O. C. MARSH,
President of the National Academy of Sciences.

APPENDICES.

APPENDIX A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, St. Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States Navy, District of Columbia; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania; J. L. LeConte, United States Army, Pennsylvania; J. Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, junior, Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SEC. 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institutions, and to report the same to Congress.

SEC. 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

Approved, March 3, 1863.

AN ACT to amend the act to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act to incorporate the National Academy of Sciences, approved March three, eighteen hundred and sixty-three, be, and the same is hereby, so amended as to remove the limitation of the number of ordinary members of said Academy as provided in said act.

Approved, July 14, 1870.

DEPARTMENT OF STATE, *June* 10, 1882.

True copies.

SEVELLON A. BROWN,
Chief Clerk.

AN ACT to authorize the National Academy of Sciences to receive and hold trust funds for the promotion of science, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the National Academy of Sciences, incorporated by the act of Congress approved March third, eighteen hundred and sixty-three, and its several supplements, be, and the same is hereby, authorized and empowered to receive bequests and donations, and hold the same in trust, to be applied by the said Academy in aid of scientific investigations and according to the will of the donors.

Approved, June 20, 1884.

DEPARTMENT OF STATE, *June* 24, 1884.

A true copy.

SEVELLON A. BROWN,
Chief Clerk.

APPENDIX B.

CONSTITUTION AND RULES OF THE NATIONAL ACADEMY OF SCIENCES.

As amended and adopted April 17, 1872, and further amended April 20, 1875, April 21, 1881, April 19, 1882, and April 18, 1883.

PREAMBLE.

Empowered by the act of incorporation enacted by Congress, and approved by the President of the United States, on the 3d day of March, A. D. 1863, and in conformity with the amendment to said act, approved July 14, 1870, the National Academy of Sciences adopts the following amended constitution and rules:

ARTICLE I.—OF MEMBERS.

SEC. 1. The Academy shall consist of members, honorary members, and foreign associates. Members must be citizens of the United States.

SEC. 2. Members who, from age or inability to attend the sessions of the Academy, wish to resign the duties of active membership, may, at their own request, be transferred to the roll of honorary members by a vote of the Academy.

SEC. 3. The Academy may elect fifty foreign associates.

SEC. 4. Honorary members and foreign associates shall have the privilege of attending the meetings, and of reading and communicating papers to the Academy, but shall take no part in its business, shall not be subject to its assessments, and shall be entitled to a copy of the publications of the Academy.

ARTICLE II.—OF THE OFFICERS.

SEC. 1. The officers of the Academy shall be a president, a vice-president, a foreign secretary, a home secretary, and a treasurer, all of whom shall be elected for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner at the session when such vacancy occurs, or at the next stated session thereafter, as the Academy may direct. A vacancy in the office of treasurer or home secretary may, however, be filled by appointment of the president of the Academy until the next stated session of the Academy.

SEC. 2. The officers of the Academy, together with six members to be elected by the Academy at the first stated session in each year, shall constitute a council for the transaction of such business as may be assigned to them by the constitution or the Academy.

SEC. 3. The president of the Academy, or, in case of his absence or inability to act, the vice-president, shall preside at the meetings of the Academy and of the council; shall name all committees except such as are otherwise especially provided for; shall refer investigations required by the Government of the United States to members especially conversant with the subjects, and report thereon to the Academy at its session next ensuing; and, with the council, shall direct the general business of the Academy.

It shall be competent for the president, in special cases, to call in the aid, upon committees, of experts, or men of special attainments, not members of the Academy.

SEC. 4. The foreign and home secretaries shall conduct the correspondence proper to their respective departments, advising the president and council in cases of doubt, and reporting their action to the Academy at one of the stated sessions in each year.

It shall be the duty of the home secretary to give notice to the members of the place and time of all meetings, of all nominations for membership, and of all proposed amendments to the constitution.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the home secretary.

SEC. 5. The treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the council may require. He shall collect all dues from members, and keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the April session. He shall be the custodian of the corporate seal of the Academy.

ARTICLE III.—OF THE MEETINGS.

SEC. 1. The Academy shall hold one stated session in each year, in the city of Washington, on the third Tuesday in April, and another may be held at such place and time as the council shall determine.

Special sessions of the Academy may be called by order of eight members of the council, at such place and time as may be designated in the call.

Scientific sessions of the Academy may be held at times and places to be designated by a majority of the council.

SEC. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SEC. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business, closed.

SEC. 4. The stated meetings of the council shall be held during the stated or special sessions of the Academy. Special meetings may be convened at the call of the president and two members of the council, or of four members of the council.

SEC. 5. No member who has not paid his dues shall take part in the business of the Academy.

ARTICLE IV.—OF ELECTIONS AND RESIGNATIONS.

SEC. 1. All elections shall be by ballot, and each election shall be held separately, unless otherwise ordered by this constitution.

SEC. 2. The time for holding an election for officers shall be fixed by the Academy at least one day before the election is held.

SEC. 3. The six additional members of the council shall be elected on any day after the first of the first stated session in each year, by each voter inscribing six names on his ballot, and those six who have received more votes than any others shall be declared elected. If two or more names have received the lowest number of votes that would elect, additional balloting shall be had for as many members as remain each time to be elected until the number is full.

The term of the members so elected shall commence at the close of the session at which they are elected, and continue until the close of the first stated session in the next year.

SEC. 4. Nominations of members may be made in writing, signed by any five members of the Academy, at any stated session, to be voted on at the next stated session held in Washington, and each nomination shall, at the time of election, be accompanied by a written list of the original works of the nominee.

SEC. 5. Elections for membership shall be held in the following manner: Each member may inscribe on a ballot not more than five names of nominees selected from the list. Absent members may send such ballots to the home secretary. From the seven names receiving the highest number of votes in this preference ballot, the members present may proceed to elect new members in the following manner: At each ballot, each member present may vote for not exceeding three persons, and the person receiving the highest number of votes shall be declared elected, provided that he received two-thirds of the votes cast, and that his name appear on not less than twenty ballots; and, provided further, that the number of members of the Academy be not already one hundred or over, in which case, to be declared to be elected, he must receive four-fifths of the votes cast, and his name must appear on at least twenty-five ballots.

Should several candidates have the same minimum number of votes on the preference list, the requisite number for completing the list shall be selected from them by a two-thirds vote of the members present.

Election of members shall be held only at the regular stated session of each year, held in Washington, and not more than five members shall be elected at that session.

Before and during elections, a discussion of the merits of nominees will be in order.

The election of members may be suspended at any time by a majority vote of the members present.

SEC. 6. Every member-elect shall accept his membership, personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SEC. 7. Foreign associates may be nominated by a committee of five members, to be appointed for that purpose by the president, and elected at any stated session by a two-thirds vote of the members present. The election shall be had by each member indicating on a ballot those names for which he votes, and those nominees whose names appear on two-thirds of the ballots shall be declared elected.

SEC. 8. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate secretary to each member on his acceptance of his membership, and to foreign associates on their election.

SEC. 9. Resignations shall be addressed to the president, and acted on by the Academy.

ARTICLE V.—OF SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

SEC. 1. Communications on scientific subjects shall be read at scientific meetings of the Academy, and papers by any member may be read by the author, or by any other member, notice of the same having been previously given to the secretary.

SEC. 2. Any member of the Academy may read a paper from a person who is not a member, and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

Persons who are not members may read papers on invitation of the president with the advice of the council.

SEC. 3. The Academy may provide for the publication, under the direction of the council, of proceedings, memoirs, and reports.

SEC. 4. Propositions for investigations or reports by the Academy shall be submitted to the council for approval, except those requested by the Government of the United States, which shall be acted on by the president, who will, in such cases, report their results to the Government as soon as obtained, and to the Academy at its next following stated session.

SEC. 5. The advice of the Academy shall be, at all times, at the disposition of the Government, upon any matter of science or art within its scope.

SEC. 6. An annual report to be presented to Congress shall be prepared by the president, and before its presentation, submitted by him, first to the council, and afterwards to the Academy, at one of the stated sessions.

SEC. 7. Medals and prizes may be established, and the means of bestowing them accepted by the Academy, upon the recommendation of the council, by whom all the necessary arrangements for their establishment and award shall be made.

Bequests and trusts having for their object the advancement of science may also be accepted and administered by the Academy.

ARTICLE VI.—OF THE PROPERTY OF THE ACADEMY.

SEC. 1. All investments shall be made by the treasurer, in the corporate name of the Academy, in stocks of the United States.

SEC. 2. No contract shall be binding upon the Academy which has not been first approved by the council.

SEC. 3. The assessments required for the support of the Academy shall be fixed by the Academy on the recommendation of the council.

ARTICLE VII.—OF ADDITIONS AND AMENDMENTS.

Additions and amendments to the constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change must be given at a stated session, and shall be referred to the council, which may amend the proposition, and shall report thereon to the Academy at the same session. Its report shall be considered by the Academy in committee of the whole for amendment.

The proposition as amended, if adopted in committee of the whole, shall be voted on at the next stated session, and if it receives two-thirds of the votes cast, it shall be declared adopted.

Absent members may send their votes on pending changes in the constitution to the home secretary in writing, and such votes shall be counted as if the member were present.

RULES.

I. In the absence of any officer, a member shall be chosen to perform his duties temporarily, by a plurality of *viva voce* votes, upon open nominations.

II. The accounts of the treasurer shall be referred to an auditing committee of three members, to be appointed by the president at the meeting at which the accounts are presented, which committee shall report before the close of that session, and shall then be discharged.

The bonds, securities, and other property owned or held in trust by the Academy shall be inspected and verified by a committee to be annually appointed by the president. The report of this committee shall be presented to the Academy at its first stated session in each year, and referred with the accounts to the auditing committee.

III. A committee of arrangements consisting of five members shall be appointed by the president for each stated session of the Academy. This committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, etc.; and to arrange the order of reading, and, in general, to attend to all business and scientific arrangements.

IV. At the meetings, the order of business shall be as follows:

1. Chair taken by the president, or, in his absence, by the vice-president.
2. Roll of members called by home secretary.
3. Minutes of the preceding meeting read and approved.
4. Stated business.
5. Reports of president, secretaries, treasurer, and committees.
6. Business from council.
7. Other business.
8. On the last day of the session, the rough minutes of that day's proceedings are to be read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless suspended by unanimous consent.

VI. Unless otherwise ordered by the Academy, the scientific meetings shall be convened at noon.

VII. The death of members shall be announced by the president on the last day of any session, when a member shall be selected by the president to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member may be selected by the president in place of the first, and so on until the duty is performed.

VIII. All discussions as to the claims and qualifications of nominees at meetings of the Academy will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the Academy at the time of the discussion.

IX. The secretaries will receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy.

X. Memoirs shall date in the records of the Academy from the date of their presentation to the Academy, and the order of their presentation shall be that in which they were registered, unless changed by consent of the author.

XI. Papers from persons not members, read before the Academy, and intended for publication, shall be referred, at the meeting at which they are read, to a committee of members competent to judge whether the paper is worthy of publication. Such committee shall report to the Academy as early as practicable, and not later than the next stated session.

XII. An annual of the Academy shall be prepared and published by the secretaries.

XIII. The printing of the Academy shall be under the charge of a committee of publication, to consist of the home secretary, and four other members to be named by the president, with the advice and consent of the council.

XIV. The annual report of the Academy may be accompanied by a memorial to Congress in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XV. The proper secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XVI. The books, apparatus, archives, and other collections of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles so deposited shall be kept by the home secretary, who is authorized to employ a clerk to take charge of them.

XVII. A stamp corresponding to the corporate seal of the Academy shall be kept by the secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels, or other proper marks of similar device, shall be placed upon objects not admitting of the stamp.

XVIII. On the first day of each stated session, immediately after calling the roll of members, a recording secretary shall be elected by a plurality of members present, to assist the home secretary in keeping the records of the session.

XIX. It shall be the duty of the committee of arrangements to fix the length of time to be devoted to reading of all papers submitted, and to limit the time to be occupied in their discussion.

XX. Ballots for election of members may be sent by sealing them up in a blank envelope, and enclosing this in another, across the back of which is written the name of the sender, and which is addressed to the home secretary; such envelopes will be opened only by the tellers.

XXI. Any rule of the Academy may be amended, suspended, or repealed on the written motion of any two members, signed by them, and presented at a stated session of the academy, provided the same shall be approved by a majority of the members present.

XXII. Nominations for membership should state the full name, residence, the official position, and the special scientific studies of the candidate. A form of nomination shall be prepared by the home secretary.

By a resolution adopted January 12, 1864, the president is, *ex officio*, a member of all Government committees of the Academy.

APPENDIX C.

ORGANIZATION OF THE ACADEMY, 1885.

	Expiration of term.
MARSH, O. C., *President*	April, 1889.
NEWCOMB, S., *Vice-President*	April, 1889.
AGASSIZ, ALEXANDER, *Foreign Secretary*	April, 1886.
HALL, A., *Home Secretary*	April, 1889.
COFFIN, J. H. C., *Treasurer*	April, 1887.

ADDITIONAL MEMBERS OF COUNCIL, 1885–'86.

BAIRD, S. F.
GIBBS, W.
HILGARD, J. E.
MEIGS, M. C.
SCUDDER, S. H.
YOUNG, C. A.

COMMITTEES OF THE ACADEMY.

On Ways and Means to Provide a Fund for the Academy.

ROGERS, FAIRMAN, *Chairman.*
CHANDLER, C. F.
MARSH, O. C.
AGASSIZ, ALEXANDER.
PUMPELLY, R.

On Weights, Measures, and Coinage.

BARNARD, F. A. P., *Chairman.*
GIBBS, WOLCOTT.
HILGARD, J. E.
MEIGS, M. C.
NEWCOMB, S.
NEWTON, H. A.
PEIRCE, C. S.
TROWBRIDGE, W. P.

On the Election of Foreign Associates.

AGASSIZ, ALEXANDER, *Chairman.*
DANA, J. D.
GIBBS, W.
HALL, A.
NEWCOMB, S.

On Reserving Public Lands on and near Mount Whitney, California, for Scientific Purposes.

LANGLEY, S. P., *Chairman.*
BREWER, W. H.
POWELL, J. W.

To co-operate with the National Board of Health.

MITCHELL, S. WEIR, Philadelphia, Pa., *Chairman.*
BARKER, GEORGE F., Philadelphia, Pa.
BILLINGS, J. S., Washington, D. C.
BREWER, W. H., New Haven, Conn.
CHANDLER, CHARLES F., New York City.
GIBBS, WOLCOTT, Cambridge, Mass.
WALKER, F. A., Boston, Mass.

On Publication.

The Home Secretary.
Baird, S. F.
Coffin, J. H. C.
Newcomb, S.
Powell, J. W.

On Publications of the Academy.

Gill, T.

On the Relation of the Academy to the Government.

The President.
Vice-President.
Secretaries.
Baird, S. F.
Coffin, J. H. C.
Hilgard, J. E.
Meigs, M. C.
Powell, J. W.

GOVERNMENT COMMITTEES.

On the Organization of the National Surveys and Signal Service.

Meigs, M. C., *Chairman.*
Brewer, William H.
Comstock, C. B.
Langley, S. P.
Newcomb, S.
Pickering, E. C.
Trowbridge, W. P.
Walker, F. A.
Young, C. A.

On the Astronomical Day, Eclipse of 1886, *and new Observatory. (Requested by Secretary of the Navy.)*

Barnard, F. A. P., *Chairman.*
Bell, A. Graham.
Dana, J. D.
Langley, S. P.
Lyman, Theodore.
Pickering, E. C.
Young, C. A.

On the Tariff Classification of Wool. (Requested by the Secretary of the Treasury.)

Chandler, C. F., *Chairman.*
Brewer, W. H.
Morton, H.

TRUST FUNDS.

Board of Direction of the Bache Fund.

Dana, J. D.
Hilgard, J. E.
Gibbs, W.

Board of Trustees of the Watson Fund.

Hilgard, J. E.
Newcomb, S.
Coffin, J. H. C.

On the Henry Draper Medal.

Barker, G. F., *Chairman.*
Gibbs, W.
Newcomb, S.
Wright, A. W.
Young, C. A.

On the Lawrence Smith Medal.

Gibbs, Wolcott, *Chairman.*
Brush, G. J.
Hall, A.
Pumpelly, R.
Rutherfurd, L. M.

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, JANUARY, 1885.

		Date of election.
Abbe, Cleveland	*Washington, D. C.*	1879
Abbot, Henry L., U. S. A	*Whitestone, Long Island, N. Y.*	1872
Agassiz, Alexander	*Cambridge, Mass.*	1866
Allen, J. Asaph	*American Museum, New York City.*	1876
Baird, Spencer F	*Washington, D. C.*	1864
Barker, George F	*Philadelphia, Pa.*	1876
Barnard, Frederick A. P	*New York City.*	——
Bartlett, William H. C	75 *Locust Hill Ave., Yonkers, N. Y.*	——
Bell, A. Graham	*Washington, D. C.*	1883
Billings, John S., U. S. A	*Washington, D C.*	1883
Brewer, William H	*New Haven, Conn.*	1880
Brooks, W. K	*Johns Hopkins University, Baltimore, Md.*	1884
Brown-Sequard, Charles E	*Paris, France.*	1868
Brush, George J	*New Haven, Conn.*	1868
Chandler, Charles F	*New York City.*	1874
Coffin, John H. C., U. S. N	*Washington, D. C.*	——
Comstock, Cyrus B., U. S. A	*Army Building, New York City.*	1884
Cooke, Josiah P	*Cambridge, Mass.*	1872
Cope, Edward D	2100 *Pine St., Philadelphia, Pa.*	1872
Coues, Elliott	*Washington, D. C.*	1877
Crafts, James M	*Ecole des Mines, Paris, France.*	1872
Dalton, J. C	43 *W. Forty-eighth St., New York City.*	1864
Dana, Edward S	*New Haven, Conn.*	1884
Dana, James D	*New Haven, Conn.*	——
Davidson, George	*San Francisco, Cal.*	1874
Dutton, Clarence E., U. S. A	*Washington, D. C.*	1884
Eads, James B	*Saint Louis, Mo.*	1872
Farlow, W. G	*Cambridge, Mass.*	1879
Ferrel, William	*Washington, D. C.*	1868
Genth, Frederick A	*West Philadelphia, Pa.*	1872
Gibbs, Josiah Willard	*New Haven, Conn.*	1879
Gibbs, Wolcott	*Cambridge, Mass.*	——
Gilbert, Grove K	*Washington, D. C.*	1883
Gill, Theodore N	*Washington, D. C.*	1873
Gould, Benjamin A	*Cordoba, Argentine Republic, S. A.*	——
Hague, Arnold	*U. S. Geological Survey, New York City.*	1885
Hall, Asaph, U. S. N	*Washington, D. C.*	1875
Hall, James	*Albany, N. Y.*	——
Hayden, F. V	1803 *Arch St., Philadelphia, Pa.*	1873
Hilgard, Eugene W	*Oakland, Cal.*	1872
Hilgard, Julius E	*Washington, D. C.*	——
Hill, George W	*Washington, D. C.*	1874
Hill, Henry B	*Cambridge, Mass.*	1883
Holden, Edward S	*Madison, Wisconsin.*	1885
Hunt, T. Sterry	*Montreal, Canada.*	1873
Hyatt, Alpheus	*Soc. of Nat. History, Boston, Mass.*	1875
Jackson, Charles L	*Cambridge, Mass.*	1883
Johnson, Samuel W	*New Haven, Conn.*	1866
King, Clarence	62 *Cedar St., New York City.*	1876
Langley, Samuel P	*Observatory, Allegheny, Pa.*	1876

		Date of election.
Leidy, Joseph	*Philadelphia, Pa.*	1884
Lesley, J. Peter	1008 *Clinton St., Philadelphia, Pa.*	—
LeConte, John	*Berkeley, Cal.*	1878
LeConte, Joseph	*Berkeley, Cal.*	1875
Lesquereux, Leo	302 *Fourth St., Columbus, Ohio.*	1864
Loomis, Elias	*New Haven, Conn.*	1873
Lovering, Joseph	*Cambridge, Mass.*	1873
Lyman, Theodore	*Brookline, Mass.*	1872
Marsh, O. C	*New Haven, Conn.*	1874
Mayer, Alfred M	*Hoboken, N. J.*	1872
Meigs, Montgomery C., U. S. A	*Washington, D. C.*	1865
Mitchell, Henry	*U. S. Coast Survey, Boston, Mass.*	1885
Mitchell, S. Weir	1332 *Walnut St., Philadelphia, Pa.*	1865
Morse, Edward S	*Salem, Mass.*	1876
Morton, Henry	*Hoboken, N. J.*	1874
Newberry, J. S	*New York City.*	—
Newcomb, Simon, U. S. N	*Washington, D. C.*	1869
Newton, H. A	*New Haven, Conn.*	—
Newton, John, U. S. A	*Army Building, New York City.*	1876
Oliver, James E	*Ithaca, N. Y.*	1872
Packard, A. S	*Providence, R. I.*	1872
Peirce, Charles S	*U. S. C. Survey, Washington, D. C.*	1877
Peters, C. H. F	*Clinton, N. Y.*	1876
Pickering, Edward C	*Cambridge, Mass.*	1873
Powell, John W	*Washington, D. C.*	1880
Pumpelly, Raphael	*Gibbs Ave., Newport, R. I.*	1872
Putnam, Frederick W	*Cambridge, Mass.*	1885
Remsen, Ira	*Johns Hopkins University, Baltimore, Md.*	1882
Rogers, Fairman	202 *W. Rittenhouse Sq., Philadelphia, Pa.*	—
Rogers, William A	*Cambridge, Mass.*	1885
Rood, Ogden N	*New York City.*	1865
Rowland, Henry A	*Johns Hopkins University, Baltimore, Md.*	1881
Rutherfurd, Lewis M	175 *Second Ave., New York City.*	—
Schott, Charles A	*Washington, D. C.*	1872
Scudder, Samuel H	*Cambridge, Mass.*	1877
Sellers, William	1600 *Hamilton St., Philadelphia, Pa.*	1873
Smith, Sidney I	*New Haven, Conn.*	1884
Trowbridge, John	*Cambridge, Mass.*	1878
Trowbridge, William P	*New York City.*	1872
Trumbull, J. H	*Hartford, Conn.*	1872
Tuckerman, Edward	*Amherst, Mass.*	1868
Verrill, A. E	*New Haven, Conn.*	1872
Walker, Francis A	*Boston, Mass.*	1878
Wood, Horatio C	1925 *Chestnut St., Philadelphia, Pa.*	1879
Worthen, A. H	*Springfield, Ill.*	1872
Wright, Arthur W	*New Haven, Conn.*	1881
Young, Charles A	*Princeton, N. J.*	1872

HONORARY MEMBERS.

Gray, Asa	*Cambridge, Mass.*
Longstreth, Miers F	*Derby, Pa.*

DECEASED MEMBERS.

	Date of death.
*Agassiz, Louis	Dec. 14, 1873
*Alexander, J. H	Mar. 2, 1867
*Alexander, Stephen	June 25, 1883
*Bache, Alexander Dallas	Feb. 14, 1867
Barnard, J. G	May 14, 1882
*Caswell, Alexis	Jan. 8, 1877
*Chauvenet, William	Dec. 13, 1870
*Clark, Henry James	July 1, 1873
*Coffin, James H	Jan. 6, 1873
Davis, Charles H	Feb. 18, 1877
Draper, Henry	Nov. 20, 1882
Draper, John W	Jan. 4, 1882
Engelmann, George	Feb. 11, 1884
*Frazer, John Fries	Oct. 14, 1872
*Gabb, William M	May 30, 1878
*Gilliss, James Melville	Feb. 9, 1865
*Gould, Augustus A	Sept. 15, 1866
Guyot, Arnold	Feb. 8, 1884
*Henry, Joseph	May 13, 1878
*Hadley, James	Aug. 1, 1864
*Hitchcock, Edward	Feb. 27, 1864
*Holbrook, J. E	Sept. 8, 1871
*Hubbard, J. S	Aug. 16, 1863
*Humphreys, A. A	Nov. 28, 1883
*Haldeman, S. S	Sept. 10, 1880
*Kirtland, Jared P	Dec. 10, 1877
*Lane, J. Homer	—— —, 1880
*Le Conte, John L	Nov. 15, 1883
*Mahan, D. H	Sept. 16, 1871
Marsh, G. P	July 23, 1882
*Meek, F. B	Dec. 21, 1877
*Morgan, Lewis H	Dec. 14, 1881
Norton, William A	Sept. 21, 1883
*Pourtales, L. F	July 17, 1880
Rodgers, John	May 5, 1882
Rogers, Robert E	Sept. 6, 1884
Rogers, William B	May 30, 1882
*Saxton, Joseph	Oct. 26, 1873
*Silliman, Benj., Sr	Nov. 24, 1864
Silliman, Benj., Jr	Jan. 14, 1885
*Smith, J. Lawrence	Oct. 12, 1883
Stimpson, William	May 26, 1873
*Strong, Theodore	Feb. 1, 1869
*Sullivant, W. S	Apr. 30, 1873
*Torrey, John	Mar. 10, 1873
*Totten, J. G	Apr. 22, 1864
*Warren, G. K	Aug. 8, 1882
Watson, James C	Nov. 23, 1880
*Winlock, Joseph	Jan. 11, 1875
*Woodward, J. J., U. S. A	Aug. 17, 1884
*Wyman, Jeffries	Sept. 4, 1874

*** Biographical notices have been presented of those designated by a *.**

FOREIGN ASSOCIATES.

Bunsen, Robert W	*Heidelberg.*
Airy, Sir George B	*Greenwich.*
Owen, Richard	*London.*
Burmeister, C. H. C	*Buenos Ayres.*
Struve, Otto von	*Pulkova.*
Adams, J. C	*Cambridge.*
Cayley, Arthur	*Cambridge.*
Clausius, Rudolph	*Bonn.*
Helmholtz, Barom H. von	*Berlin.*
Kirchoff, G R	*Berlin.*
Pasteur, Louis	*Paris.*
Stokes, G. G	*Cambridge.*
Srlvester, J. J	*Oxford.*
Hooker, Sir J. D	*Kew.*
Thomson, Sir William	*Glasgow.*
Auwers, Arthur	*Berlin.*
Bertrand, J. L. F	*Paris.*
Huxley, T. H	*London.*
Virchow, Rudolph von	*Berlin.*
Berthelot, M. P. E	*Paris.*
Boussingault, J. B. J. D	*Paris.*
Chevreul, M. E	*Paris.*
De Candolle, Alphonse	*Geneva.*
Kölliker, Albert von	*Würzburg.*
Oppolzer, Theodore von	*Vienna.*
Richthofen, F. von	*Berlin.*

DECEASED FOREIGN ASSOCIATES.

Sir Wm. Rowan Hamilton.
Karl Ernst von Baer.
Michael Faraday.
L. Elie de Beaumont.
Sir David Brewster.
G. A. A Plana.
F W. A Argelander.
Friedrich Wohler.
J. B. Dumas.
Henry Milne-Edwards.
Michel Chasles.
Sir Roderick I. Murchison.
Victor Regnault.
H. W. Dove.
C. A. F. Peters.
Justus von Liebig.
Alexander Braun.
Joachim Barrande.
Adolphe Würtz.

APPENDIX D.

REPORT ON THE ASTRONOMICAL DAY, THE ECLIPSE OF THE SUN IN 1886, AND THE ERECTION OF A NEW NAVAL OBSERVATORY.

[CORRESPONDENCE.]

YALE COLLEGE,
New Haven, Conn., December 4, 1885.

SIR: I have the honor to transmit to you herewith a report made by a committee of the National Academy of Sciences on the questions relating to the Astronomical Day, the Eclipse of the Sun in 1886, and the Erection of a new Naval Observatory, as submitted to the Academy by you, in a communication dated April 22, 1885.

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

The Hon. SECRETARY OF THE NAVY.

NAVY DEPARTMENT,
Washington, D. C., April **22, 1885.**

Prof. O. C. MARSH,
President of the National Academy of Sciences:

SIR: I have the honor to submit inclosed a copy of Senate Executive Document No. 78, Forty-eighth Congress, second session, containing a letter from the Secretary of the Navy, dated February 17, 1885, transmitting communications concerning the proposed change in the time for beginning the astronomical day, as recommended by the recent Meridian Conference.

I would respectfully request that the National Academy of Sciences take into consideration the question of adopting the proposed change in the American Ephemeris and Nautical Almanac, and other astronomical publications, and advise this Department of its views and recommendations on the subject.

I have also the honor to submit for your consideration and recommendation the following questions:

(1) As to the advisability of asking Congress to make an appropriation for the observation of the eclipse of the sun in August, 1886, to be

expended by the Superintendent of the Naval Observatory under direction of the Navy Department.

(2) As to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880.

Very respectfully,

W. C. WHITNEY,
Secretary of the Navy.

YALE COLLEGE,
New Haven, Conn., April 27, 1885.

The Hon. the SECRETARY OF THE NAVY:

SIR: I have the honor to acknowledge the receipt of your communication of the 22d instant, and to inform you that in compliance with the request therein contained, I have appointed a committee from the National Academy of Sciences, to report upon the important questions you have submitted to the Academy.

The committee is as follows:

President F. A. P. Barnard, Columbia College, New York, *Chairman.*
Prof. Graham Bell, Washington, D. C.
Prof. J. D. Dana, Yale College, New Haven, Conn.
Prof. S. P. Langley, Observatory, Allegheny, Pa.
Hon. Theodore Lyman, Brookline, Mass.
Prof. E. C. Pickering, Harvard Observatory, Cambridge, Mass.
Prof. C. A. Young, Princeton Observatory, Princeton, N. J.

This committee represents several branches of astronomy, as well as other allied departments of science, and will give the question submitted to them careful consideration.

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

REPORT.

Prof. O. C. MARSH,
President of the National Academy of Sciences:

SIR: The undersigned, a committee appointed by you to consider and report upon certain matters concerning which the Secretary of the Navy has solicited the advice of the Academy, have attended to the duty assigned them, and respectfully report as follows:

The questions above referred to, as submitted by the Secretary to the Academy, are three, viz:

(1) As to the expediency of making the change in the time of beginning the astronomical day recommended by the International Meridian Conference in 1884.

(2) As to the advisability of asking Congress to make an appropriation for the observation of the total eclipse of the sun to occur in August, 1886.

(3) As to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880.

I.—THE ASTRONOMICAL DAY.

In regard to the first of the questions here presented, it appears to the undersigned that there are two points to be considered: first, how far the proposed change in the time of beginning the astronomical day is desirable in itself; and, secondly, whether, supposing it to be so, it is expedient to make the change in the American Ephemeris and Nautical Almanac forthwith, and without waiting for, or soliciting the concurrent action of others.

The usage of astronomers, which makes noon instead of midnight the beginning of the day for their uses, was adopted without any reference to, or thought of, the purposes of general chronology; but was determined by the simple fact that the sun's meridian passage can be directly observed. Having been adopted, it has entered into all the literature of astronomical science from the time of Ptolemy down to the present day. It has moreover become inwrought into all the habits of thought of the astronomical and nautical world; while those who are neither navigators nor astronomers have so infrequent occasion to concern themselves with the computations of astronomy, that the discrepancy between astronomical and civil reckoning is rarely brought to their attention, and by many is not even known to exist.

The proposed change is therefore not called for in order to remove any serious existing inconveniences; while, if made, it will be attended with the disadvantage of introducing an interruption of continuity between the astronomical records of the past and those of the future, so that the astronomers of coming centuries will be unable to make use of the tables and ephemerides heretofore constructed, without allowing for a difference of twelve hours.

It is true that the existing state of things may be a source of occasional uncertainty to the astronomer as to the exact date of a phenomenon reported to have taken place, as when, for instance, a remarkable comet or meteor may be said to have been observed on a given day between midnight and sunrise. During this period, the astronomical and civil time dates differ by a unit, and there may be doubt which of these times was intended; but this uncertainty will not exist in case the number of the hour as well as that of the day be stated, because in civil time the hour will be below 12, and in astronomical time above.

It is an apparent objection to astronomical time reckoning that it divides the natural day—that is, the day between sunrise and sunset—into parts distinguished by different dates. For the ordinary purposes of life, the natural day is a unit, and cannot be counted otherwise without confusion. The solar eclipse of August, 1886, for example, begins generally upon the earth by civil reckoning in the morning of the twenty-ninth day of the month, and ends in the afternoon of the same day, but by astronomical time, it begins on the twenty-eighth and ends on the twenty-ninth. If this mode of counting dates should be extended to the record of historical events, it is easy to see how great must be the consequent confusion.

But the fact that the discrepancy between the two different modes of time reckoning has not been felt as an important embarrassment in the astronomical world is evidenced by the almost absolute silence concerning it which characterizes the great mass of astronomical literature. The only astronomer of distinction by whom it is mentioned, so far as the knowledge of the committee extends, is Sir John Herschel, who, in his "Outlines of Astronomy," remarks, "This usage" [beginning the day at noon instead of midnight] "has its advantages and disadvantages, but the latter seem to be preponderate; and it would be well if, in consequence, it could be broken through, and the civil reckoning substituted."

While, however, the existence of the discrepancy under consideration cannot be regarded as a source of serious inconvenience, it must be admitted that, in the interests of simplicity, it is desirable that it should disappear. The director of the Greenwich Observatory made early announcement of the purpose there to begin the change on the 1st of January, 1885; and though in reply to a question from Commodore Franklin, superintendent of our Naval Observatory, he stated later that this was "for internal use, awaiting official communication before introducing generally," it sufficiently indicates the preference of the astronomers at that establishment. Early in December, 1884, Commodore Franklin announced that the same change would be made at the Naval Observatory at the same date; but this order was subsequently withdrawn in deference to objections raised by Professor Newcomb, superintendent of the American Ephemeris. Immediately after this, the expediency of the proposed change was submitted, by a circular issued by Commodore Franklin, to a large number of American astronomers, and the replies of nine out of eleven of these were favorable, the remaining two only giving a qualified dissent. This dissent relates not so much to the change itself as to the time of making it.

In view, then, of the general consensus of the astronomers of our own country in favor of the proposed change, and of the adhesion to the same view of so important an institution as the Royal Observatory of England, the committee are disposed to advise that the change should be made. The question follows, therefore, whether it is advisable to make the change without further delay in the American Ephemeris and Nautical Almanac, and other astronomical publications issued in this country, or whether it should be postponed until a general concurrence in the measure can be secured of the astronomical world elsewhere, in order that the change, when made, may be made simultaneously everywhere.

Arguments have been urged on both sides of this question. On the one hand it has been said that, inasmuch as the Meridian Conference was assembled on the call of the United States, there is a certain fitness in a prompt acquiescence on our part in the recommendations of that body. It has, moreover, been argued that our example would doubtless exercise an important influence in disposing favorably to the measure minds otherwise inclined to hesitate. Of the astronomers who expressed their opinions on this point in answer to the circular issued by Commodore Franklin, the majority favored the immediate adoption of the mode of reckoning recommended by the Meridian Conference. The minority, however, objected to isolated action in a matter of such importance, arguing, with apparent justice, that unnecessary confusion would be the consequence of the introduction of the change into different ephemerides at different dates. To this it has been added that the ephemerides prepared by maritime nations for the use of their navigators are already completed and published in advance as far forward as the year 1888; and that it would be an indefensible incongruity for any government to require one description of time reckoning to be employed in the current work of the astronomers in its service, and another in its astronomical publications covering the same period.

The committee have further reason to believe that, while there is a general disposition on the part of the astronomers of Great Britain and the United States to accept the proposed change, the feeling toward it on the continent of Europe is less favorable. It is to be hoped, and indeed may be presumed, that time will remove this adverse disposition if it exists, and that, before the close of the century, a harmony of opinion on the subject, which is already general, may become universal.

At the recent meeting of the international association entitled the *Astronomische Gesellschaft*, held at Geneva in August last, this question was considered and discussed at some length, but was left undecided. The discussion may be resumed hereafter, and should the conclusion be favorable, the association may name a time at which the change may be everywhere simultaneously made.

The committee regard favorably the proposition of the Meridian Conference on this subject, and recommend that the change should be made as soon as sufficient concert of action can be secured among the leading astronomers and astronomical establishments of the civilized world—in 1890, if practicable; if not, in 1900.

II.—THE SOLAR ECLIPSE OF AUGUST, 1886.

The second of the questions submitted by the Secretary inquires as to the expediency of asking Congress for an appropriation to provide for the observation of the total solar eclipse of August, 1886. Were it highly probable that under the circumstances observations could be secured which would be of material gain to knowledge, the committee would not hesitate to reply promptly in the affirmative. No class of celestial phenomena has furnished more valuable contributions to our knowledge of the physical condition of the sun, and of the stellar universe generally, than is afforded by these eclipses. It is this which has prompted and justified the large expenditure of time and labor which has been devoted to the preparation and dispatch of expeditions for the observation of these phenomena when they take place, as happens frequently, on distant and inhospitable parts of the earth's surface.

The eclipse of August 29, 1886, will be total only in the torrid zone, and the path of the total phase will fall mainly in the open Atlantic Ocean; but at Benguela, on the western coast of Southern Africa, it will be observable at about three o'clock of local time in the afternoon. The hour will be very favorable to observation at that station, and provided that the hygienic and meteorological conditions prevailing there at the same time can be presumed to be equally so, it would seem to be desirable that advantage should be taken of them.

Commodore Belknap, the present Superintendent of the Naval Observatory, has kindly furnished to the committee information as to these particulars in the form of a report made to himself by Lieut. C. C. Cornwell, U. S. N., who appears to have been instructed to make inquiry in regard to them. As to the meteorological conditions, the conclusions of Lieutenant Cornwell seem to be inferences derived from observations made at Loando, about 3 degrees north of Benguela, on the same coast, but subject to substantially the same climatic vicissitudes. He says "the foggy season extends from May till the end of August, and this is the best and most healthy time of the year for Europeans." The report gives the number of days during the month of August at which the sky was comparatively clear or not more than three fourths overcast at the hours of 9 a. m., 12 m., or 3 p. m., for six successive years, from 1879 to 1884 inclusive; deducing the result that "the probability of good weather at 3 p. m., the time of the eclipse, is as 18 to 13," not much more than an even chance; but, it is added, "it is to be remembered that the conditions at the end of the month are much more favorable." As to healthfulness, Lieutenant Cornwell says, "In conversation with Captain Crispo, of the Portuguese navy, who was for a number of years the governor of Massamedes (about 3 degrees south of Benguela), I gathered that it would be perfectly safe for a party to spend the month of August on the coast without danger to health, and that there was nothing to fear from wild beasts."

These statements are in great measure reassuring, if not wholly so. It would be preferable, if it were possible, to have some direct and official testimony as to the effects of a climate so generally believed to be deleterious upon natives of the temperate zones, rather than be obliged to rely, in a matter of so prime importance, upon what appears to be merely hearsay.

Were the proposed observing station within moderate distance, the uncertainty as to favorable atmospheric conditions would be of comparatively little consequence. The question becomes more serious when the station can only be reached by a voyage extending to more than a quarter of the earth's circumference. The distance by great circle from New York to Benguela is nearly 6,000 nautical, or 7,000 statute, miles. With any vessel likely to be assigned by the Government to the duty of transporting an observing party for this purpose, the transit could hardly be accomplished in less than a month. The selection of a site for the observing station, the erection of temporary shelter for the party, the installation of instruments, the necessary preliminary observations for latitude and longitude, and the calculation of the circumstances of the eclipse for the exact locality, all which things should be deliberately done, would occupy not less than a fortnight; so that the expedition, in order that it may have a reasonable prospect of success, should leave New York not later than the middle of July.

A doubt here presents itself whether, in case Congress should respond favorably to a request for an appropriation for this object, the action of that body would be likely to take place early enough to allow time for the proper outfit of the expedition and the necessary drill of the observers in the methods of observation to be employed. It may be necessary, and probably will be, to construct instruments for the uses of the expedition, for, though it is understood that there are telescopes at the Naval Observatory which have been employed on former similar occasions, and which may suffice for direct observation, the records of the eclipse which will have the highest value will be such as will have to be secured by photographic impressions of the successive aspects. It is possible that the instruments employed for this purpose in the transit of Venus expeditions may have been preserved; but even if that is the case, modifications suggested by experience, or designed to adapt the apparatus to the special objects aimed at in the present instance, will doubtless be required. For in addition to the observation of the sun itself, and the luminous phenomena attending it, it is desirable to obtain photographic maps of all the surrounding region to the distance of at least ten or fifteen degrees from the sun, for the purpose of finally setting at rest the still mooted question of an intra-mercurial planet. It is true that the astronomical world is at present disposed generally to discredit the existence of such a body, yet the evidence on the subject up to this time is mainly negative, as it must always continue to be so long as it depends upon direct vision. In a photographic map, taken during total eclipse of the sun, of the whole region within which such a planet must necessarily be confined, the object, if present, must present itself, and could not fail to be recognized. But, for photographic operations of this class, lenses of wide angle must be specially prepared, differing essentially in character from those which are employed to take impressions of the eclipse.

During what is called the long session of Congress, definite action is rarely secured upon any important measure until late in the spring, or in the early months of the summer, and this is especially true of money bills. If an astronomical expedition is to be sent out under the auspices of the Government not later than the 15th of July, the fact ought to be certainly known as early as March at least, in order that the preparation may be made with such deliberation and thoroughness as to insure satisfactory results. Considering the usages which have seemed to govern Congressional legislation in the past, the committee are apprehensive that even in case provision should be ultimately made for the expedition under consideration, it would come so late as to be unavailable, or would compel a preparation so imperfect and hurried as to be inadequate to accomplish satisfactorily the objects in view.

Taking all these reasons into consideration, the committee decline to recommend the application for an appropriation.

III.—THE OBSERVATORY.

The third of the questions submitted by the Secretary appears to the committee to possess a higher importance than attaches to either of the others. It inquires as to "the expediency of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880."

It is now many years since the question of the removal of the Observatory was first agitated. The Board of Survey created by act of Congress in 1872, of which the Chief of Engineers, General A. A. Humphreys, was chairman, recommended that the Observatory should be removed to a better site; adding that the sale of the grounds attached to the present building would probably furnish the means of making the necessary purchase elsewhere. As a principal reason for such removal it was stated that the present site of the Observatory will be needed for projected city improvements. The suggestion of this report produced no immediate effect; but after the accession of Admiral John Rodgers, in 1877, to the Superintendency of the Observatory, the question was revived, and the removal was earnestly pressed. In a letter addressed by Admiral Rodgers, in September of the year just named, to the Secretary of the Navy, it was recommended "that a suitable site north of the city, and inside the District of Columbia, be procured for a new Observatory," for the reasons, first, "that the malarious influences surrounding it [the present Observatory] are notorious, and that from May to about the middle of October, the officers, whose services are necessarily in the Observatory at night, pay the penalty in impaired health and diminished efficiency." Secondly, that "the fogs which arise from the river, driven by the prevailing winds, float above the instruments and lessen their usefulness." And thirdly, that "the present Observatory is in a very dilapidated condition." In support of these statements, Admiral Rodgers presented the written testimony of eminent medical men residing in Washington, some of them officially attached to the naval service; and also that of several of the astronomers whose work is at the Observatory, all of whom concur in the opinion that the present site is seriously if not dangerously unhealthy. To this cause Medical Director Clymer does not hesitate to ascribe the early death of Captain Gilliss, Superintendent of the Observatory from 1861 to 1865; and Professor Yarnall expresses the opinion that the maladies by which Professors Ferguson and Hubbard, and Assistant Moses Springer were carried off were produced or fatally aggravated by the same injurious influences. It is further testified by the same authority, that every family which has resided in the Observatory building has suffered more or less severely, Admiral Sands having been at one time "reduced to the edge of the grave." In like manner the observers who, though living by day in more healthful quarters, were obliged to attend at the Observatory at night, in the discharge of their regular duties, were, almost without exception, subject to chills and fever.

In regard to the second objection—the interference by fogs with the work of observation—the testimony is unanimous as to the fact of the evil, but is greatly conflicting as to its magnitude. Thus, Professor Yarnall says that "generally the condition of the atmosphere is favorable to observation, except in the fall, principally in September and October, we have often to stop work from the fogs which arise from the river after midnight." Professor Hall says, "My experience is that the observations which are chiefly affected by the river fogs are those of faint objects, like comets, and the small planets, when observed at a low altitude. During the summer and fall, it not unfrequently happens that observations of such objects are prevented by these fogs." Professor Harkness testifies that "occasionally, on an otherwise clear night, a slight mist rises from the river; but it is rarely so dense as to interfere appreciably with meridian work, although, perhaps, it may sometimes prove an impediment in the case of very faint objects." Professor Eastman writes: "At intervals throughout the year, and on nearly every night from May to December, the surface of the Potomac River in the vicinity of the Observatory is covered toward the latter part of the night with a mass of vapor and fog, which rises to such a height as completely to envelop the Observatory, and is so dense as seriously to interfere with all observations of small objects." He adds: "The heated air over the dwellings north of the Observatory seriously interferes in the winter with the definition of all objects within 25° of the horizon, and the increase in the number of buildings in that section of the city augments the difficulty every year." Professor Holden, after mentioning his opportunities to observe at West Point and at the observatory of Dr. Henry Draper on the Hudson at Hastings, continues: "My invariable experience has been that the atmospheric conditions obtaining at Washington for objects of low altitude are less favorable than those of the other observatories in question; and this I attribute almost entirely to the proximity of the Naval Observatory to the river, whose fogs and vapors exert a decidedly hurtful influence upon the astronomical work."

As to the third consideration bearing on removal, viz, the condition of the Observatory building, we have the statement of Admiral Rodgers, made in 1877, that it would require $29,909.35 to put it, at that time, in suitable repair. Commodore Belknap, the present Superintendent, writes under date of October 26, 1885: "The dilapidated condition of 1877 is replaced by a still more dilapidated one in 1885; the observing rooms (except that of the transit circle) are small and ill-constructed; the dome of the great equatorial is badly warped, requiring a four-horse-power engine to move it; the surroundings of the dome are in bad repair, and the buildings generally are ill-adapted to the purpose of an observatory; the 9.6 inch equatorial room is in direct communication with the main building, and the currents of heated air which rise therefrom greatly interfere with the efficiency of the instrument." Commodore Belknap further represents that the library, which is large and very valuable, is not properly accommodated, and that there is no suitable provision for the storage and preservation of the records. It may be added that the building is not fire-proof, and that the destruction of the library by fire would involve the loss of many priceless works which cannot be replaced. The present building appears, moreover, to be faulty in plan. In a letter of Professor Newcomb, addressed to Admiral Rodgers in 1877, it is stated that "the present building is entirely inadequate to the needs of a national scientific establishment, having been built more than thirty years ago, when American astronomy was in its infancy. The large and valuable library of the Observatory is outgrowing the limits which can be provided for its accommodation, and is now housed in what was formerly an observing room, where its proper protection from the vicissitudes of the weather is hardly possible. There is no proper place to store the records of observations and calculations made during the period now including thirty-two years; and the instruments used in the observations of the late transit of Venus have mostly to be stored in a small room where they are greatly exposed to destruction by fire. The architecture of the present building is such that it cannot be readily enlarged to meet the increasing wants of the establishment. One of the principal instruments of the Observatory (the prime vertical transit) has to remain unused, because the room in which it is placed is appropriated as a store-room and passage-way combined."

On the evidence as thus presented, the case would seem hardly to admit of doubt. The conclusion is almost forced upon us that, whatever may be done about the erection of a new Observatory, every consideration, sanitary, scientific, and economical, requires that the present site and the present structure should be abandoned.

There is something, however, to be said on the other side. The citations above given are mainly drawn from documents prepared eight years ago. The sanitary question, which is by far the most serious one, has, since that time, assumed a different aspect. The Observatory site has not always had the malarious character which has in recent years made it so nearly uninhabitable. It owes its unhealthiness to the formation of marshy flats, in consequence, it is said, of the obstruction to the flow of the river by the building of the Long Bridge. These flats are now in process of being rapidly filled up, and it is the belief of some of the medical men of Washington that with their reclamation the deleterious influences of which they have been the cause will cease to be exerted. Others of the profession, however, take a different view; and while authorities equally entitled to respect are thus at variance among themselves, it seems to be the duty of this committee to give a greater weight to the certainty of the present than to the possibilities of a doubtful future.

In regard to the obstruction to observation by fogs, the quotations above given, though they make the most of this difficulty, show nevertheless that it is not a matter of gravity. Professor Holden, whose opinion is perhaps the least favorable of those expressed in 1877, says now, in a letter before the committee, "the river fogs alone are not a sufficient cause for removal." Professor Newcomb, whose continuous service for sixteen years at the Observatory thoroughly familiarized him with all the advantages and disadvantages of the place, is silent on the subject; so that it may be inferred that he considers the difficulty too unimportant for mention.

As for the dilapidated state of the building, that may be a reason for repairing, or, if necessary, for reconstructing it; but it is not in itself a reason for a change of site. But if, as appears to be the case, the present site is objectionable on other and more serious grounds, the defective condition of the building deserves consideration as suggesting that the present is a favorable time for abandoning it. But at this point, the question naturally arises, whether, in case a new Observatory should be erected on the site purchased in 1880, it would not be advisable to give to the new institution so erected a larger usefulness than can belong to an astronomical establishment assumed to have been designed to subserve only the wants of a single branch of the public service.

The honorable Secretary, in employing the phrase "Naval Observatory," instead or saying "Observatory" merely, has seemed to submit the question whether, in the opinion of the Academy, the interests of the *Navy* require that a new Observatory should be erected. The committee have therefore sought to ascertain what are the special services rendered by the Observatory to the Navy, or what are the relations of the establishment to that branch of the public service which justify the epithet *Naval*. This title has never been conferred upon it by law, nor is it that by which it was first known. The Observatory commenced its operations in the autumn of 1844, and its first volume of observations was published in 1846 under the title "Astronomical Observations made during the year 1845, at the National Observatory, Washington; published by authority of the Hon. George Bancroft, Secretary of the Navy." Volume II of the series was published in 1851, by authority of the Hon. William A. Graham, Secretary of the Navy under President Fillmore. In a letter addressed in 1854 by Lieut. M. F. Maury, then Superintendent of the Observatory, to Commodore Charles Morris, Chief of the Bureau of Ordnance and Hydrography, of which a copy has been furnished to the committee by Commodore Belknap, it is stated that "the Observatory was christened 'National' by Mr. Bancroft [the first Secretary of the Navy under President Polk] in a letter of March 6, 1846, relating to the labors to be undertaken at the *National* Observatory. Its observations (1st Vol.) were published under that title by his authority, and not that of the Bureau.* Commodore Morris appears to have been dissatisfied with this state of things, and on the 11th December, 1854, he made an appeal on the subject to the Hon. J C. Dobbin, Secretary of the Navy under President Pierce, who promptly replied, "My opinion is that it [the Observatory] should be styled 'The U. S. Naval Observatory and Hydrographic Office.'" Thus one Secretary overrules the decision of one of his predecessors, and the practice sanctioned by two of them, and arbitrarily changes the name which has been borne by a public institution, with the perfect acquiescence of Congress and the people, for nearly ten years. Mr. Dobbin founded his ruling on the considerations that "It [the Observatory] has always been under the control of the Navy Department, and it is conducted by Navy officers, both in its superintending and somewhat subordinate duties."

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*Vol. I of the series, published in 1846, has two title-pages, one of them in letter press and printed as part of the first form; the other engraved, and inserted apparently afterward. The original and regular title-page designates the Observatory as "the National Observatory"; in the one later inserted it is called "the U. S. Naval Observatory." A presentation slip inserted between the two is as follows: "Presented to ——— by the U. S. Naval Observatory, Lieut. M. F. Maury, U. S. N., Superintendent." This makes it apparent that the change from *National* to *Naval* was made by Lieutenant Maury on his own responsibility. But as Vol. II, published in 1851, had also two title-pages with the word National in full in both, and as the same was true of Vol. III, published in 1853, the evidence is pretty strong that this act of the Superintendent did not meet with the approval of the Department. Vol. IV gave in both titles the initials U. S. N. Observatory, which may read National or Naval at pleasure. In later volumes the engraved title disappears.

In the appropriation bill approved August 3, 1848, a clause was inserted providing that the Superintendent "shall be either a captain, a commander, or a lieutenant in the Navy," but Lieutenant Maury did not regard this as justifying a change of title in the published observations, and no change was made until after the ruling of Secretary Dobbin, in 1854. Moreover, previously to this ruling, the Observatory was referred to in the annual appropriation bills either as "the National Observatory" or "the United States Observatory," both these forms appearing in the bill approved March 3, 1855, three months after the ruling. The term "Naval Observatory" first appears in legislation in the appropriation bill approved August 16, 1856.

By a special act of Congress, approved March 3, 1865, the provision of the appropriation bill of 1848, requiring that the Superintendent of the Observatory should be a naval officer, was repealed.

These things were indeed true as facts, and indeed there was a temporary requirement of law, introduced, in accordance with a practice by no means to be commended, into an appropriation bill, directing that the Superintendent should be a naval officer. But when Mr. Dobbin goes on to say further, "It is a Navy affair, and its reputation is the property of the Navy," he asserts what was hardly true at the time, and what, in the subsequent history of the establishment, has been still less so. For the reputation which the Observatory has acquired has been a reflection of the personal luster of individual men appointed to it from civil life, and whose most brilliant works have been accomplished quite independently of their routine duties at the Observatory.

The fact that the Observatory is under the control of the Navy Department does not necessarily give it the character of a naval establishment. The Museum of Hygiene is under the same Department, but it is not called a naval museum. The Marine Hospital Service is under the Treasury Department, but this is not because it has any affinity with the business of collecting and disbursing the revenues, but simply because it is seemingly proper that every branch of the public service should be subject to the control of some Executive Department. It was by a very simple series of events that the Observatory fell under the supervision of the Secretary of the Navy. Some years before the erection of the present Observatory building, there was established on Capitol Hill an office of modest pretensions, styled a "Depot of Charts and Instruments," of which the character is described in its title. Here nautical chronometers were regulated, reflecting instruments regulated and tested, and charts deposited, to be supplied whenever needed to our public armed vessels. After the erection of the Observatory, these duties were transferred to that establishment; and while it remained in this embryonic condition there might perhaps have been a certain propriety in calling it a naval observatory; but the service it rendered to the Navy required no astronomical instrument for its satisfactory performance more than a small meridian transit. The variety of superior instruments with which the new structure was furnished invited, however, to the prosecution of researches purely scientific; and the consequence has been the publication up to this time of about thirty volumes of observations, embracing between five and ten thousand pages, not one in a hundred of which is probably of any especial concern to the Navy.

In 1866, the charts and nautical instruments were removed from the Observatory to the Hydrographic Office in the Navy Department. The chronometers remain, and the rating of these time-pieces is the only substantial link by which the Observatory maintains a practical connection with the naval service. Secretary Dobbin, in the order by which he transformed the name of the Observatory, making it *naval* after it had been for ten years known only as *national*, seems to rest for the justification of his proceeding on the fact that "it has always been conducted by Navy officers," a fact certainly, but a fact for which for several years after it was founded there existed no requirement of law, and for which there exists none now. This fact, however, is undoubtedly the principal ground on which the claim that the Observatory should be called a naval institution must rest—it has always had a naval officer, usually an officer of rank, at its head. Junior naval officers have, moreover, been frequently sent there to be trained in methods of observing, and sometimes to be charged with the duties of observers without training, or at least without adequate training. This seems, however, to be a very subordinate branch of naval education. If this were not the case, however, the fitness of things would seem to suggest that provision should be made for the training of these officers at Annapolis rather than at Washington. There is already an observatory at Annapolis; but the course of instruction pursued at the naval school there is of itself evidence how little importance is considered in naval education to attach to the processes of practical astronomy as conducted in fixed observatories. All the astronomical training which the naval cadets receive is confined to the principles of navigation and the use of portable reflecting instruments. It is believed that the observatory of the Academy is not used at all, and has not been for many years; and the neglect of it would appear to show that the naval officers stationed there have not the time to occupy themselves with subjects so far outside of the necessities of their professional life.

But if it should appear to Congress, or to the leading minds in the naval service, that a certain number of the junior officers of the Navy ought to be familiarized with the use of fixed astronomical instruments, then propriety would appear to suggest that the educational institution which was expressly established to give to young men the knowledge of other subjects necessary to qualify them for duty in the naval service should furnish them also their proper instruction in this. Let for this purpose the observatory of the Academy, if necessary, be enlarged, and if the additional duty consequently imposed upon the present staff of instructors is likely to overtask them, let their number be increased. Let also the business of rating the chronometers be transferred from Washington to Annapolis; and then we shall have an observatory which may properly be called *naval*.

The work by which our Washington Observatory has made itself known, that which has given it the honorable reputation it enjoys, has been work which has been undertaken and successfully accomplished purely in the interest of astronomical science. It is such work as is done at Greenwich, at Pulkova, at Paris, and at other national observatories. The heaviest part of this work consists of those observations of standard stars, of the planets, and of the moon, which are necessary to the perfection of the nautical ephemerides, on the accuracy of which the art of navigation and the security of the mercantile, no less than of the naval marine are so entirely dependent. This is the kind of work in which the usefulness of a public observatory is most directly felt. It is the kind of work which makes the existence of public observatories a necessity; for its monotony is such as to offer no attractions to private observers, who naturally devote themselves to researches which hold out the fascinating hope of discovery.

But researches of this latter character form also a part of the work of public observatories, though they constitute no part of their necessary duties. And there can be no doubt that it is to the success of such incidental labors, when they are successful, that such institutions owe in large part the reputation they acquire. The honorable Secretary Dobbin, in 1854, claimed that even at that early day, when it had been only ten years in existence, our National Observatory had already achieved an enviable reputation—a reputation which he claimed as the property of the Navy. But at that time, the institution had published but two volumes of observations, and the reputation it had acquired was due almost wholly to the brilliant success of Prof. Sears C. Walker, one of its civilian astronomers, in determining, in 1847, the orbit of the then recently discovered and distant planet Neptune. And Admiral Rodgers, in enumerating at a later day the grounds on which the Observatory may fairly claim to rank among the first institutions of its class in the world, finds nothing to say of its relations to the Navy except the following: "It co-operates with the Navy in determining positions abroad. It is the depot where the chronometers for the Navy are kept and rated, and from which naval vessels are supplied with them on being placed in commission. Its appliances are always open to officers of the Army and Navy who wish to avail themselves of them in determining positions." On the other hand, he speaks of "the furtherance of navigation" as "the legitimate work of the Observatory," this being a service of larger importance to the merchant marine than to the naval, in the proportion in which the number of ships engaged in commerce exceeds that of those created to meet the exigencies of war. And speaking further of its valuable services to the country and to science, he says, "It is in nearly constant co-operation with the Coast Survey and with the heads of exploring parties, in determining the latitudes and longitudes of cities, boundary points, and important stations in every part of the States and Territories." He adds, "All longitudes in this country are now, in the first place, determined by means of, or are referred to this Observatory." He attributes to the Observatory credit also for dropping time-balls from its own dome and in the city of New York; for lending essential aid to the American Ephemeris and Nautical Almanac by perfecting the tables indispensable to the navigator and the astronomer; for a persistent study, pursued through years, of the moon's irregularities, with a view to the correction of the still outstanding errors of the lunar tables; for the star catalogues prepared for publication by Professor Yarnall, commended in the report of the council of the Royal Astronomical Society of

London, in 1874, as "a valuable contribution to observing astronomy; the catalogue containing 10,658 observed stars, and including many observed in the Army and Coast Surveys, and many from Lacaille's catalogue not hitherto observed"; for Professor Newcomb's valuable contributions to the volumes of observations for 1865, 1870, and 1873; for Professor Holden's interesting papers "relating to the Ring Nebula in Lyra, the Trifid Nebula, the Satellite of Uranus, and other astronomical topics"; for the discovery by Professor Ferguson of Euphrosyne, the first of the planetoids discovered in this country; for the discovery by Professor Hall of the two satellites of Mars, and so on; and he shows, from the extent of space given in the German Astronomical Review and the Monthly Notices of the Royal Astronomical Society of London, to the work of our Washington Observatory as compared with others, that in the estimation of European astronomers, our Observatory ranks among the first in the world. Indeed, he states that an authority so high as Father Secchi, of Rome, puts Pulkova, Greenwich, and Washington together in the foremost rank of astronomical institutions.

The claims here made are all of them just, though in some instances it has been the merit of the individual observer, of which the Observatory has enjoyed the benefit, since much of the most creditable work has been supererogatory rather than obligatory. Still, it cannot be denied that it has been the Observatory which has afforded to these successful laborers the opportunity to put forth their strength, and furnished the stimulus which has animated them to effort. The honorable reputation of the institution has even been enhanced by labors undertaken by some of its observers independently of their professional duties as connected with it, and of which the results have been given to the world through different channels. This is especially true of the colossal labors of Professor Newcomb in his "Theory of Neptune" and his "Investigations of the Orbit of Uranus," published in the Smithsonian Contributions to Knowledge, and in his "Theory of the Perturbations of the Moon produced by the Planets," published in Liouville's Journal, Paris, of which it was remarked by Professor Cayley, president of the Royal Astronomical Society, that "it contains the successful development of a highly original idea, and cannot but be regarded as a great step in advance in the method of the variation of the elements, and in theoretical dynamics generally."

All these specifications, however, creditable as they are to the Observatory, are illustrations of the services it has rendered, not to the Navy, but to the art of navigation and pure astronomical science. It has served for our country the purpose on account of which the observatory at Greenwich was avowedly founded, two hundred years ago, for England; and that for which, within the present century, the observatory at Pulkova was founded for Russia; that is to say, notwithstanding its name, its labors have been actually conducive to the common good of the nation, and have not been restricted to the special benefit of any particular branch of the public service. And such, should it be maintained, will continue to be the character of its work, whatever may be the title by which it shall be known. But that its title should be in harmony with the nature of its work, would seem to be a dictate of the simplest common sense. In the view of the committee, therefore, should a new observatory be erected, whether on the site of the present one, or on that which was purchased in 1880, or anywhere else, at the cost of the Government, it should not be a Naval, but a National Observatory.

Having become thus assimilated in title, as it already is in its work, to the institutions of similar character maintained by the governments of other enlightened nations, it would seem that it should, like them, be placed under a direction in harmony with its objects. No one can have a higher respect for the gallant officers of our Navy than the members of this committee, or those of the National Academy; but it implies no disrespect to them to say that there is nothing in their professional education, and nothing in the nature of their active duties in the service, to familiarize them with the processes of astronomical observation, or to acquaint them with the construction and uses of fixed astronomical instruments. There have been exceptional cases, indeed, in which a naval officer has been an accomplished astronomer. This was especially true in the case of Capt. J. M. Gilliss, who had the direction of the Observatory from 1861 to 1865, and of Admiral C. H. Davis, his immediate successor, who held the position from 1865 to 1867. When astronomers like these are to be found in the Navy, it is quite fitting that they should be placed at the head of our National Astronomical Observatory; but, in the view of the committee, a line officer of the Navy not thus specially qualified is as much out of place as superintendent of a great astronomical establishment as a civilian astronomer would be if placed in command of a fleet of armed vessels in time of war.

There is another consideration which bears seriously upon the expediency of appointing naval officers to fill this important post, whatever may be their scientific qualifications—it is the brevity of the time during which they are permitted to enjoy this honorable distinction. The exigencies of the naval service are continually imposing upon the Department the necessity of ordering them to other fields of activity, often before they have had time to familiarize themselves with their duties in this temporary post. It is now just forty-one years since the Observatory commenced its operations, and it has had already, including the present incumbent, nine different Superintendents, of whom one was a second time appointed after an interval of seven years, making ten different administrations, and giving an average term of incumbency of four years and one-tenth. The only Superintendent who seems to have held office with anything resembling permanence was Lieutenant Maury, the first on the list, whose term of service extended from 1844 to 1861, seventeen years, and who then voluntarily abandoned his post; but Lieutenant Maury had been disabled by an accident from active service in the Navy before his appointment to the Observatory, and hence was disqualified except for some such position as that which he held in the Observatory. Deducting these seventeen years, there remain twenty-four during which there have been nine successive administrations, with an average term of service of two years and eight months. And in the list of Superintendents during this period are two who held the position for less than one year.

Now, in any human undertaking whatever, nothing can be less favorable to the attainment of satisfactory results than continual change in the directing head. And that which would be universally regarded as inadmissible in a business enterprise, seems to be still more so in an institution established and operated in the interests of exact science. The examples of foreign observatories illustrate the importance attached to this consideration in other countries. Francis Arago held the post of director of the Paris Observatory for twenty-three years; Frederick William Bessel was at the head of the Koenigsberg Observatory for forty years; and George Biddel Airy was astronomer Royal at Greenwich for nearly fifty years, the term of service in the first two of these instances being ended only by death.

Upon the point now under consideration, the committee have found a letter addressed to Admiral Rodgers by Professor Newcomb, in 1877, in reply to the question "Whether it is more advantageous that the Superintendent should be a line officer of the Navy or a practical astronomer," which so perfectly expresses their own view that they do not hesitate to adopt it entire. Professor Newcomb says:

> I am of opinion that the establishment should have a scientific head for these reasons:
>
> 1. The generally recognized necessity that every office should, so far as practicable, be under a head professionally acquainted with its routine of business, exists here. The most important duty of the Superintendent is to see that the observations made and the work performed are those most advantageous for the objects with which the institution was founded; that the calculations are correctly made; and that harmonious co-operation is secured among the various departments. The securing of these objects requires a permanent policy, which can only be inaugurated by a scientific head. As illustrative of this view, I may cite the fact that during one-fourth the existence of the Naval Observatory, the publication of the annual volume of observations was entirely omitted, for the reason that only one or two observers made any observations worth publishing. The most important want of national astronomy at the present time is general tables of the stars and planets corresponding to the present state of practical astronomy; and it is a want which can, in its full extent, be supplied only by a large and well-organized observatory, securing the co-operation of many minds in the work of observation and calculation. I am unable to see how such a work as this can be successfully executed except under constant scientific supervision of the establishment.
>
> 2. It seems to me that a new Observatory should be built, and administered with some one or more well-defined objects in view, and that these objects should be those of the fulfillment of which science stands most in need. Scientific control in some form would, I think, at least tend to assure the public that this end was being secured, though it might be executed by a commission or a board as well as by a single person.

3. I think that individual astronomers of talent are more secure in the recognition of their scientific claims under a head professionally interested in the advancement of science. It is a part of the law of scientific publication—unwritten, indeed, but universally recognized in the scientific world—that every man doing original work should be recognized in its publication as the author of it. But, during more than half of the existence of the Naval Observatory this right was not recognized, the name of the author being either entirely suppressed, or only mentioned in some other place than the title-page of the work. That this is not now the case is due solely to the liberality of yourself and of your immediate predecessors.

The committee anticipate the objection that, inasmuch as the Observatory, on their own showing has, during the forty years of its existence, enjoyed an honorable reputation, though always during the same period under the direction of a line officer of the Navy who has not himself been usually an accomplished astronomer, this experience of the past is a practical demonstration of the fact that a scientific head is not necessary to insure to such an institution the attainment of the most satisfactory results. This argument admits of being inverted, or stated conversely, as thus: The experience of the past demonstrates that a body of conscientious and faithful workers in the scientific field can attain creditable results and achieve an honorable reputation, in spite of the absence of an intelligent directing mind to systematize their work and to constrain them into harmonious co-operation to the attainment of a distinctly defined common object.

The reputation of the Observatory, as has been already remarked, rests very largely upon the admirable results attained by individual civilian members of its astronomical staff in researches undertaken of their own proper motion, and not prescribed by the superintending authority, or even assigned to them by any common agreement among themselves. Such are the labors, already referred to, of Professor Walker on the orbit of Neptune, the discoveries of Professors Ferguson and Hall, the observations of Professor Holden on the nebulæ, especially the nebula of Orion, the admirable contributions of Professor Newcomb to the published volumes of Observations, to say nothing of the extraordinary investigations undertaken by this last-named gentleman outside of his regular work in the Observatory. But productions of this kind, however brilliant and however admirable, furnish us no evidence of the kind of system which governs the operations of the Observatory, nor even evidence that such system exists at all. They are proofs that good work is done by subordinates, but testify nothing as to the capacity of the administrative head.

Achievements like these, however, which are the results of individual endeavor, form no part of that special description of systematic work for the sake of which national observatories are necessary, and for the prosecution of which the earliest observatories were founded. At the time of the discovery of America by Christopher Columbus, the navigator had no better means of determining his place at sea, than the method of dead-reckoning, dependent on log and line and the magnetic needle.

The alarm of that adventurous navigator when he discovered that the needle was not constant in its direction is matter of history. Previously to this time few navigators had the daring to venture far from land; but the demonstrated existence of a new continent teeming with riches stimulated frequent voyages upon the open ocean; and the perplexing "problem of the longitude," as it was called, attracted the earnest interest of every maritime people. Tempting rewards were held out to any person who should successfully solve this baffling problem. In 1598, Philip III of Spain offered to this end a reward of 1,000 crowns. The Dutch states followed with a higher offer of 10,000 florins. The British Parliament, in 1714, proposed a grand prize of £20,000 for a method which should determine the longitude at sea within 30 geographical miles; also a less prize of £15,000 for a method true within 40 miles, and another still of £10,000 for one true within 60. In 1716, France offered for a similar purpose a prize of 100,000 livres. In 1674, during the reign of Charles II of England, a method was presented to the British court for determining the longitude by means of observations of the moon's distance from fixed stars near its path—the method still known and practiced under the name of "the method of lunar distances." This plan having been submitted to Flamsteed, then the most eminent of British astronomers, was pronounced by him to be useless on account of the errors of the tables. Of astronomical tables then existing, the best were those of Tycho Brahe, and the place of a ship as determined by them might possibly be in error to the enormous extent of 900 miles. It was this state of things which led to the establishment of the Royal Observatory at Greenwich, and shortly after, of that at Paris, examples which have since been followed by the governments of all considerable nations which have a maritime population and commerce. Of the Greenwich Observatory, it has been remarked that "that single institution has done more for the increase of the world's wealth than would have sufficed to support at their ease all the astronomers and physicists that ever lived since the days of Hipparchus; to build and furnish all the observatories the world ever saw; to establish and endow all the universities, colleges, and schools of every grade from highest to lowest throughout the globe; to erect and provide for all the hospitals, almshouses, and eleemosynary institutions of every kind in all civilized lands; and to build all the churches and parsonages, as well as to defray all other expenses attendant on the support of religion in every Christian country from the advent of our blessed Savior down to the present hour. To make even a conjectural estimate of the true value of its services to mankind would, from the nature of the case, be impracticable, since the elements which must enter into such an estimate are as numerous as the endlessly varied articles of human consumption. It is even impossible to make a comparative estimate of the value of astronomical agency considered along with other agencies concerned in promoting the same interests, since all the improvements of art or science which tend to give increased development to commercial enterprise, and all the stimulating influences which incite men to engage or encourage to continue in commercial pursuits, steal from astronomy at least half their efficiency, by availing themselves of the security which that science has provided for the immense aggregate of treasure constantly afloat upon the waves."

The immense service here so emphatically described as rendered to mankind by the Greenwich Observatory has been accomplished simply by making it a possibility to find the longitude of a ship at sea by astronomical methods. And this result has been attained by so careful, systematic, and persistent observation of the more conspicuous members of the solar system, and of the principal stars in and near the zodiac, as to give to the solar, lunar, and planetary tables and to the star catalogues such a degree of accuracy as to permit the future aspects of the heavens to be correctly predicted. This it is which constitutes the proper and essential business of a state observatory. Two centuries ago, when the first state observatories were founded, the errors to be corrected were so enormous as to make the first steps toward this correction comparatively easy, but the process by which these great errors were eliminated has still constantly to be repeated, since the tables of celestial movements are by no means yet perfect, and the apparent places of the stars, as determined by their spherical co-ordinates, are undergoing constant though gradual change through their own proper motions, and in consequence of the precession of the equinoxes. Though, therefore, navigation by the stars has been reduced to a science of extreme accuracy, it can only be maintained in that character by unwearied persistence in the same description of observations by which it was originally made so.

It is accordingly the fidelity with which it follows up this species of work, and not its occasional discoveries of comets or minor planets, or its studies of curious objects like Saturn's rings or remarkable nebulæ, which is to be the test of the intelligence with which the operations of a state observatory are conducted, and of the competency of the directing head. It is, consequently, to the published observations of the observatory that we must look for the means of forming a judgment in regard to it upon these points. If we examine the series of volumes put forth by our Observatory, at first under the name of National and afterwards under that of Naval Observatory, we shall detect features which are far from satisfactory. At first, we shall notice that there occur unexplained gaps in the series—entire years passing which leave no record behind them; and secondly, we shall observe that when observations of certain objects were actually pursued from year to year, they are not steadily continuous or uniform in frequency; also that, before the installation of the transit circle in 1866, and when two instruments were necessary for the determination of the place of a star, viz, the simple transit for the right ascension, and the mural circle for the declination, these two instruments appear to have been worked without preconcert on the part of the observers. Sometimes stars which were observed on one day with one instrument were observed on a different day with the other. Occasionally objects which were observed for a long period of time with one of the instruments, were not observed with the other at all. In reference to these points attention is called to the letter of Professor Newcomb, addressed to the chairman of the committee, which is appended to this report.

The publications of the Observatory itself, therefore, show sufficiently the absence of any preconceived plan directing its operations; and this fact is a sufficient response to the argument that it has attained an honorable reputation while under the superintendency of naval officers who were not astronomers.

It can hardly be doubted that our Observatory will continue to be maintained, whether it be perpetuated as an appendage of the naval service, or raised to the dignity implied in the more honorable title of National Observatory. Our country has been too large a participator in the benefits conferred by astronomy upon navigation, and through navigation upon commerce, and through commerce upon national wealth, to permit her to repudiate the obligations under which the history of her past prosperity has laid her to this noble science, or to permit her, even in view of her own material interests, to neglect to continue the provisions by which only these benefits can be perpetuated. Nor is it conceivable that among our statesmen it can be regarded as consistent with a proper national self-respect that this enlightened Government shall fail to extend an encouraging hand to a science which, for the past two centuries, all civilized and Christian peoples have vied with each other in fostering. The United States of America outnumber in population any modern Christian people except Russia; and at the present rate of increase, they will, in two or three decades, exceed not only in numbers, but in wealth and in military strength, every other nation of the civilized world. The time is soon coming when the sails of the American Republic will cover, as they have done in years past, every sea, and her flag will fly in every accessible port. Such a nation cannot fail to do as much for the science which has made navigation possible, as at least such comparatively feeble states as Spain, Portugal, and the Argentine Republic, the last named of which has recently established at its capital, Cordoba, a noble observatory, in which our accomplished countryman, Dr. B. A. Gould, has, within the past fifteen years, achieved a work of almost superhuman magnitude, and which is destined to be a perpetual monument to his masterly intellect and his energy, perseverance, and skill as an observer. We ought rather to emulate the liberality of the most powerful states, like Russia, which, at Pulkova, has reared in recent times the most splendidly equipped temple to astronomical science yet anywhere existing.

That Congress appreciates the obligation of our people toward this branch of science is manifest in the legislation of nearly half a century in regard to it; in the erection of a costly building which, though now perhaps dilapidated and otherwise inadequate to the increasing needs of science, was originally at least beautiful in appearance and convenient in plan; in its original equipment of instruments equal to any of their time; the provision in 1866 of a splendid transit-circle, and the purchase a few years later of the great 26-inch equatorial, at the time, the most powerful telescope in the world, and now surpassed by only two others; with finally the purchase in 1880 of a new and admirable site, free from the objections which have been found to exist to the present one, for the erection of a new and more convenient edifice; these successive acts prove that the advancement of astronomical science has been long a settled part of the policy of our National Legislature, and furnish an assurance amounting to a moral certainty, that if the present Observatory should be abandoned, it will be only to erect another and a better one elsewhere.

It ought certainly to be a better one. If, in the completeness of its provisions to secure satisfactory results, it shall correspond in any degree to what the position of our people among the nations of the earth would suggest, and would seem to require, it would be the most perfectly appointed establishment of its kind hitherto created, and would stand conspicuous among the monuments by which enlightened peoples signalize to surrounding nations their moral and intellectual superiority.

The necessity of abandoning the present site, suggested as probable by the Government Board of Survey in 1872, and recognized to-day as imperative, affords a very opportune occasion for the early realization of this noble aspiration, and for enabling our Government, while carefully guarding the interests of the Navy, whether scientific or educational, to fulfil suitably the weighty obligations under which it lies to that science which has done more than any other to build up the wealth of nations. Let all those instruments in the present Observatory which can be of service to the Navy, with so many of the astronomical staff as may be needed to use them, be transferred to Annapolis, and let the observatory of the Naval Academy, strengthened by these accessions, be styled the Naval Observatory. Let the remaining instruments, which will probably be the 26-inch telescope, the transit-circle, and the prime vertical transit, be reserved to be installed in a new edifice to be erected upon the site purchased in 1880, in conformity with designs prepared after consultation with the most experienced astronomers of the country, including present and former members of the astronomical staff of the Observatory itself; and let this new structure be styled the National Observatory of the United States. Precedents for the distribution of duty here proposed may be easily found, if required. Spain maintains at her capital an observatory devoted to the interests of pure astronomy, while she has another at Cadiz styled a naval observatory. Austria has an imperial royal observatory at Vienna, and a naval observatory at Pola on the Adriatic. Germany has a principal observatory at Berlin, and a so-called marine observatory at Wilhelmshafen.

In like manner, Russia has, at Pulkova, the most splendidly endowed establishment for the promotion of astronomical science in the world, and a minor one for marine uses at Odessa. France, also, besides her great observatory founded in the seventeenth century at Paris, has, it is believed, another at Cherbourg connected with her naval service. In all these cases, it will be noticed that the naval observatory is situated in a sea-port town. The arrangement, therefore, here proposed, conforms to precedent not only in principle, but also in this rather important detail.

In view of all these considerations, the committee unanimously concur in the following conclusions, viz:

1. It is advisable to proceed promptly with the erection of a new observatory upon the site purchased in 1880 for this purpose.

2. It is advisable that the observatory so erected shall be, and shall be styled, as the present Observatory was styled originally, the National Observatory of the United States, and that it shall be under civilian administration.

3. It is advisable that the instruments in the present Observatory, with the exception of the 26-inch telescope, the transit circle, and the prime vertical transit, shall be transferred to the observatory at Annapolis, with such members of the astronomical staff as may be required to operate them; also that such books of the library as relate chiefly to navigation shall take the same destination; the instruments above particularly specified, with the remainder of the library, being reserved as part of the equipment of the new National Observatory, to which also the remaining officers of the astronomical staff shall be assigned for duty.

4. It is advisable that the observatory at Annapolis should be enlarged, if necessary, and adapted to subserve as effectually as possible the wants of the naval service, whether practical, scientific, or educational; that it shall be under the direction of the Department of the Navy, and shall be styled the Naval Observatory of the United States.

Appended to this report will be found documents showing the authority under which the committee has been constituted, and also a selection from those bearing upon the subjects considered, which have been laid before them during their deliberations,

All which is respectfully submitted.

F. A. P. BARNARD,
Chairman.
A. GRAHAM BELL.
J. D. DANA.
S. P. LANGLEY.
THEODORE LYMAN.
E. C. PICKERING.
C. A. YOUNG.

COLUMBIA COLLEGE,
New York, November 30, 1885.

APPENDIX.

The documents contained in this appendix are as follows:

1. Letter of the Secretary of the Navy to the President of the National Academy of Sciences, asking the advice of the Academy upon certain questions.
2. Letter of President Marsh, naming a committee of members of the Academy to consider and report on the questions of the Secretary.
3. Letter of the chairman of the committee to the Secretary of the Navy.
4. Letter of Commodore George E. Belknap, Superintendent of the Naval Observatory, transmitting information in regard to the meteorology and healthfulness of Benguela, South Africa.
5. Extract of letter from Commodore Belknap, transmitting correspondence relating to the title of the Observatory.
6. Correspondence transmitted, viz: A. Extract from a letter of Lieut. M. F. Maury, Superintent of the Observatory, to Commodore Charles Morris, Chief of Bureau of Ordnance and Hydrography. B. Letter of the Hon. J. C. Dobbin, Secretary of the Navy, to Commodore Morris.
7. Letter of Commodore Belknap on the disadvantages of the present site of the Observatory.
8. Document referred to in the foregoing.
9. Letter of chairman of committee to Commodore Belknap.
10. Reply of Commodore Belknap to the foregoing.
11. Extracts from letters of Prof. E. S. Holden, late director of the Washburn Observatory, Madison, Wis., and now president of the University of California, and director of the Lick Observatory.
12. Letter of chairman of committee to Prof. S. Newcomb.
13. Reply of Professor Newcomb.
14. Comment of Commodore Belknap on Professor Newcomb's reply.
15. Letter of Dr. F. M. Gunnell.
16. Letter of Dr. James E. Morgan.
17. Letter of Dr. J. S. Billings.
18. Letter of Dr. D. R. Hagner.
19. Letter of Dr. William Lee.
20. Letter of Dr. T. J. Turner.

No. 1.—*From the Hon. Secretary of the Navy to the President of the National Academy of Sciences.*

NAVY DEPARTMENT,
Washington, D. C., April 22, 1885.

Prof. O. C. MARSH,
President of the National Academy of Sciences:

SIR: I have the honor to submit, inclosed, a copy of Senate Executive Document No. 78, Forty-eighth Congress, second session, containing a letter from the Secretary of the Navy, transmitting communications concerning the proposed change in the time for beginning the astronomical day, as recommended by the recent Meridian Conference.

I would respectfully request that the National Academy of Sciences take into consideration the question of adopting the proposed change in the American Ephemeris and Nautical Almanac, and other astronomical publications, and advise this Department of its views and recommendations on the subject.

I have also the honor to submit for your consideration and recommendation the following questions:

1. As to the advisability of asking Congress to make an appropriation for the ob-

servation of the eclipse of the sun in August, 1886, to be expended by the Superintendent of the Naval Observatory under direction of the Navy Department.

2. As to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880.

Very respectfully,

W. C. WHITNEY,
Secretary of the Navy.

No. 2.—*From the President of the National Academy of Sciences naming a committee of the National Academy of Sciences to consider the questions of the Secretary.*

YALE COLLEGE, NEW HAVEN, CONN.,
April 28, 1885.

DEAR SIR: I inclose herewith a copy of a communication from the Secretary of the Navy, requesting the National Academy of Sciences to take into consideration the following questions:

(1) The proposed change in the time for beginning the astronomical day, as recommended by the recent Meridian Conference.

(2) As to the advisability of asking Congress to make an appropriation for the observation of the eclipse of the sun in August, 1886.

(3) As to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880.

In compliance with this request, I have appointed the following committee from the National Academy of Sciences:

President F. A. P. Barnard (chairman), Columbia College, New York.
Prof. Graham Bell, Washington, D. C.
Prof. J. D. Dana, Yale College, New Haven, Conn.
Prof. S. P. Langley, Observatory, Allegheny, Pa.
Hon. Theodore Lyman, Brookline, Mass.
Prof. E. C. Pickering, Harvard Observatory, Cambridge, Mass.
Prof. C. A. Young, Princeton Observatory, Princeton, N. J.

I have sent to each member of the committee a copy of this communication from the Secretary of the Navy, and shall transmit later some official documents bearing upon the questions submitted to the Academy.

Requesting that you will send me the report of the committee not later than the first of November next,

I remain, very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

President F. A. P. BARNARD,
Columbia College, New York.

No. 3.—*From the chairman of the committee to the honorable the Secretary of the Navy.*

COLUMBIA COLLEGE,
New York, June 11, 1885.

Hon. W. C. WHITNEY,
Secretary of the Navy:

DEAR SIR: The President of the National Academy of Sciences has appointed a committee, of which I have the honor to be chairman, to consider and report upon certain questions addressed by you to him in a communication of the 22d of April, 1885, concerning which you desire an expression of opinion of the Academy. The most important of these relates to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880.

The answer to be given to this question must very much depend upon the functions which it is desired or designed that the Observatory shall in future fulfil. Its title, *Naval Observatory*, conveys the implication that its duties and uses are to be purely practical, and such as are required for the purposes of the Navy as a branch of the public service. In the beginning this was doubtless strictly its character; for it was originally established under the name of a Depot of Charts and Instruments, and it continued to be known by this title for several years. Since the erection of the present Observatory, however, the scope of its operations has been much enlarged, and its usefulness has consisted quite as much in its contributions to the advancement of astronomical science as in its practical services to the Navy, and, indeed, in the view of the Academy, much more. Congress seems even to have made a distinct recognition of the propriety of its application to promote scientific discovery, by appropriations for the purpose, and especially by the appropriation for the construction of the great 26-inch telescope.

If the operations of the Observatory are to be conducted hereafter to any considerable extent, avowedly for the advancement of science no less than for the uses of the Navy, the question as the expediency of proceeding with the erection of a new building upon the site purchased in 1880 is greatly simplified, and, in fact, that admission is sufficient to decide it; but the same admission raises at once another question which, without having been directly submitted to the Academy, is necessarily involved in that which is actually presented. This question is that of the organization of the working astronomical corps, and the direction of the operations of the Observatory.

As a branch of the naval service, the Observatory has always heretofore been under the direction of a line officer of the Navy. Considered as an institution created wholly or partially for the service of science, it is obvious enough that it should be directed by a head selected with especial reference to his proficiency in the science it is intended to promote. It has happened in the past that the Department has been able to find in the naval service men of such character as astronomers as fairly to fit them for this important post. A man more competent than Captain Gilliss, for example, could hardly be found, either in the naval service or among civilians. Captain Maury, Capt. C. H. Davis, afterward admiral, Capt. John Rodgers, also afterward admiral, were gentlemen admirably qualified for the same trust; but the naval service does not, as a rule, furnish opportunity to officers to become experts in practical astronomy, and its active duties will generally interfere a good deal in the study of astronomical theory. If, therefore, at any time the service should not be able to furnish a man whose qualifications to act as director of the Observatory should be fully recognized in the scientific world, it is desirable that the Department should be at liberty to place in that responsible post a properly qualified civilian.

It seems to be important, therefore, if Congress should be asked to make appropriations for the erection of a new Observatory on the site selected in 1880, that such legislation should at the same time be sought as should leave the Department free to choose a director either from the naval service or from civil life, as the Secretary should think best for the public interest. The committee of the Academy could only think of recommending further expenditure by the Government on behalf of the Observatory on the condition that such provision in regard to future direction should be made part of the law; but supposing that provision secured, there can be no doubt that the committee and the entire Academy will, with one voice, advise the erection of the proposed new building. In the absence of such a provision, I think they would prefer to be excused from offering any advice.

Now, my reason and my apology for addressing to you this communication is, that the committee is likely to desire, before making their report, to be ascertained that their recommendation, whatever it may be, shall not be such as to affect the susceptibilities of the officers of the naval service. The Observatory is now by law a branch of the service, and it may be that such officers as are possibly in the line of advancement to the position of director may regard it as a grievance if legislation should be asked for which should remove the possibility of such promotion. In conversation with some officers in the service, I have found that this feeling does not exist, and I hope it may not be entertained by any. I have thought that you might be able to give me such information upon this point as to remove the embarrassment of the committee. I therefore respectfully solicit an expression of your opinion upon the subject as early as may be convenient.

It has been suggested that, in case the new Observatory should be built, the old one might be continued also in operation; and that a distribution of duties might be made which should give the old building entirely up to the Navy with a naval officer for director, while the new one might be confined to work strictly in behalf of science. I should be happy to be informed what view you would be disposed to take of such a proposition.

I am, sir, very respectfully, your obedient servant,

F. A. P. BARNARD,
President Columbia College,
Chairman of committee.

No. 4.—*From Commodore George E. Belknap, Superintendent of the Observatory, to the chairman of the committee.*

UNITED STATES NAVAL OBSERVATORY,
Washington, October 2, 1885.

SIR: I have the honor to inclose herewith, for the information of the committee of the National Academy of which you are chairman, some data concerning the surroundings of Benguela, Africa, on the line of totality of the eclipse of August 29, 1886.

Very respectfully,

GEO. E. BELKNAP,
Commodore, U. S. N., Superintendent.

Prof. F. A. P. BARNARD,
President of Columbia College, New York.

[Inclosure in the foregoing.]

Extract from a report, relative to the healthfulness and meteorological conditions of Benguela, Africa, on the line of totality of eclipse of August 29, 1886, made by Lieut. C. C. Cornwell, U. S. N., to the Superintendent of the Naval Observatory.

* * * * * * *

"From the meteorological observatory at Lisbon I learned that there were no meteorological reports received from Benguela, but that those from Loando were believed to apply equally well to the former place. The foggy season extends from May till the end of August, and this is the best and most healthy time of the year for Europeans. August is the last month of the fogs at Loando, but probably the season lasts somewhat longer at Benguela.

"During the season, the fog is thick in the morning, especially at sunrise; it clears away about noon, and 3 p. m. is the most favorable time for observations. The following table gives the number of days during the month of August for six years, and at the times indicated, that the sky was either clear, slightly cloudy, or not more than three-fourths covered:

Year.	9 a. m.	Noon.	3 p. m.	Mean temperature in August during these years.
1879	6	5	15	19. 3 centigrades.
1880	5	9	9	
1881	5	9	15	
1882	12	17	21	
1883	2	5	9	
1884	8	11	19	

"The probability of good weather at 3 p. m., the time of the eclipse, is as 18 to 13; but it is to be remembered that the conditions at the end of the month are much more favorable. There are several places in the vicinity of Benguela where an observing station might be established. *Mount Sombrero* (St. Philip's Bonnet) is a headland on the coast about six miles from Benguela, and 150 meters in height. There is a practicable road to this point, constructed for the use of keepers of the light-house which is situated about half way up the hill. *Catumbella* is a village situated on the right bank of the river of the same name, and is a place of some importance, having a fortress and being a place of resort and safety. It is about 10 miles to the northward of Benguela.

"On the left bank of the river is a hill, with a house at its summit, which was formerly the residence of the military commander of the post. This would seem to be a good place to establish a station, as it is easily accessible from Benguela, being connected with it by a good road.

"*Lobito Bay* is about 10 miles north of Catumbella, and is an excellent sea-port, but there is no easy method of reaching it except by sea. There are no houses here, and there is some difference of opinion as to there being any fresh water in the immediate vicinity. The neck of land forming the bay would seem to be a favorable place for establishing a station, providing the party were independent of the surrounding country for its food and water supply.

"*Mount Agulhas*, which is known in Portugal as *Sierra das Bambas*, being really a chain of mountains, is about six miles south of Benguela, on the road to the village of Dombe. It is a sterile spot, with no water in the vicinity, which can be secured no nearer than *Guipupa*, and it is here of a chalybeate nature. * * *

"In conversation with Captain Crispo, of the Portuguese navy, who was for a number of years the governor of Massamedas, I gathered that it would be perfectly safe for a party to spend the month of August on the coast without danger to health, and that there was nothing to fear from wild beasts."

No. 5.—*From Commodore Belknap to chairman of the committee.*

UNITED STATES NAVAL OBSERVATORY,
Washington, November 6, 1885.

* * * With regard to the nomenclature of the institution, I beg to send for your information a copy of a letter from the Department to the Superintendent during the administration of Mr. Pierce. Also extract from a letter written by Lieutenant Maury to Commodore Morris in 1854, concerning the same matter.

Respectfully and sincerely yours,

GEO. E. BELKNAP.

President F. A. P. BARNARD.

No. 6 (A).—*Extract from a letter dated December* 8, 1854, *from Lieut. M. F. Maury, Superintendent of the Observatory, to Commodore Charles Morris, Chief of Bureau of Ordnance and Hydrography.*

* * * * * * *

The Observatory was christened "National" by Mr. Bancroft in a letter of March 6, 1846, relating to the labors to be undertaken at the *National* Observatory. Its observations (first volume) were published under that title by his authority and not by that of the Bureau.

Respectfully, &c.,

M. F. MAURY.

No. 6 (B).—*From the honorable, the Secretary of the Navy, in* 1854, *to Commodore Charles Morris, Chief of the Bureau of Ordnance and Hydrography.*

NAVY DEPARTMENT, *December* 12, 1854.

SIR: In reply to your letter of the 11th instant asking some official decision upon the name by which the establishment now under the immediate superintendence of Lieut. M. F. Maury shall be designated, my opinion is that it should be styled "The U. S. Naval Observatory and Hydrographical Office." It has always been under the control of the Navy Department; it is conducted by Navy officers, both in its superintending and somewhat subordinate duties. It is a Navy affair, and its reputation is the property of the Navy. If it assume another name and character, the next step will be to place a civilian at its head.

I am decidedly of opinion it should retain its present character and connection with the Navy.

Very respectfully, your obedient servant,

J. C. DOBBIN.

Commodore CHAS. MORRIS,
Chief of Bureau of Ordnance and Hydrography.

No. 7.

UNITED STATES NAVAL OBSERVATORY,
Washington, October 26, 1885.

Dr. F. A. P. BARNARD,
President of Columbia College, New York:

DEAR SIR: In response to your letter of the 7th instant, concerning the erection of the new Naval Observatory, I have the honor to inclose herewith a copy of a public document issued in 1877 upon this subject. The reasons assigned in this pamphlet for the necessity of a removal seemed so cogent that Congress in 1880 appropriated the money for the purchase of a site and the preparation of the plans of the building. The next session was a short one, and nothing was done in the matter; the succeeding year Admiral Rodgers' death caused a cessation of active efforts to obtain the necessary appropriation.

The reasons which existed in 1877 still exist. The filling in of the flats will not obviate the trouble from malaria which afflicts those who are obliged to be on the premises at night, as the marshy banks on the opposite side of the river will continue to be a fruitful source of miasma which will be borne to the Observatory by the prevailing winds.

The dilapidated condition of 1877 is replaced by a still more dilapidated one in 1885; the observing-rooms (except that of the transit circle) are small and ill-constructed; the dome of the great equatorial is badly warped, requiring a four-horse power engine to move it; the surroundings of the dome are in bad repair, and buildings generally are ill-adapted for the purposes of an observatory; the 9.6-inch equatorial room is in direct communication with the main building, and the currents of heated air which rise therefrom greatly interfere with the efficiency of the instrument. Then, too, the offices are inadequately heated, the apparatus for that purpose being of an old style and of insufficient capacity to answer the demands upon it. The library (which is becoming larger and more valuable with each succeeding year) is not properly accommodated, and there is no suitable place for the storage of the records. The efficiency of the observing force is also injured by the fact that the observers live at a distance from their instruments, and hence much less work is done than would be possible at the new site, where the plans provide for quarters within the inclosure.

The "seeing" here is also very poor, owing to the great dampness, &c.; but thirty-eight nights of 1884 were recorded as *good*, while eighty were *poor*, and on the remaining two hundred and thirty it was not clear enough for observing. This year about the same proportion of good nights has been noted. The very good nights of a year could be counted with a single digit. It is believed that the seeing at the new site is much better.

The situation of the present buildings with reference to the surrounding neighborhood is by no means what it ought to be as regards isolation. The inclosed extract from the report of a board of experts (composed of President Barnard and Professors Rowland and Hastings) shows how great stress should be laid upon this point.

I am of opinion that the best interests of the scientific side of the institution will be decidedly subserved by its removal to the new site. The plans are all prepared, and have been submitted to the criticism of the leading scientific men of the country, and their suggestions have received due consideration. That something must be done is obvious to one who visits the present site. Your attention is respectfully called to the estimate of Admiral Rodgers for the repair of these buildings in 1877; but even then there would remain the malaria and the absence of the observers from the scene of action as hindrances to the full activity of the institution.

Very respectfully, your obedient servant,

GEO. E. BELKNAP,
Commodore, U. S. N., Superintendent.

No. 8.—*Document referred to in the foregoing. Extract from report made in* 1881 *to Hon. William P. Whyte, the Hon. Leopold Morse, and Admiral John Rodgers, Commissioners appointed under act of Congress to select a site for the erection of a new Naval Observatory.*

* * * * * * *

Before proceeding to details, it may be well to state what, in the view of the undersigned, should be the characteristics of a spot fixed on to be the site of a working observatory. Such a site should in the first place be located where it may command an atmosphere as steadily unobscured and as uniform in density as the general conditions of the climate will allow. It should, therefore, be remote from factories or clustered dwellings which by the smoke of their many fires tend to vitiate the clearness of the air. There should not be in the vicinity any large surfaces of earth unclothed with vegetation and thus exposed to be heated to excess by the direct rays of the summer's sun, and so to generate rising currents of unequal density which may distort the figure and disturb the steadiness of the images of celestial objects. For the same reasons, massive architectural structures in the neighborhood must be regarded as objectionable, even though artificial fires may not be maintained in them, and on this account alone, public highways, if their neighborhood were not otherwise prejudicial, should be kept at as great a distance as possible.

But a still more serious objection to the vicinity of public highways is found in the tremors, occasioned by vehicles rolling over them, in the instruments of the observatory. This is an evil of so grave importance as to form an objection absolutely conclusive against any proposed site liable to be affected by it. Persons without experimental knowledge of the subject can have no just idea of the facility with which tremors even from causes apparently slight, are transmitted through the earth. No degree of massiveness in a structure will exempt it from liability to such disturbance, for the reason that the motion is not that of the mass itself, but that of its molecules which are successively displaced. An ordinary milk cart in the streets of New York will often cause the chandeliers in a dwelling perceptibly to tremble. This is most strikingly the case in parts of the city where the pavements and the dwellings rest equally on an underlying rock of indefinite extent; since the rock by its elasticity transmits tremors more freely than loose sand or soft earth. It is for this reason that in the construction of an observatory, the floors of the observing rooms are not allowed to touch the piers on which the instruments rest, lest the movements of the observer himself should disturb his instrument.

An astronomical observatory ought therefore, if possible, to be placed at a distance from all the great thoroughfares; and though such a location diminishes facility of access to it, yet considering the purposes for which such establishments are created, there seems to be nothing objectionable in this. National Observatories have not been founded by Governments simply out of the generous desire to promote the advancement of science. The motive which has prompted their erection has been far less disinterested than this, and is found in the encouragement such institutions afford to commerce by the security with which they surround navigation. It is probable that no appropriations from the public treasury of any commercial nation have ever been repaid so many thousand-fold as those which have been made for the improvement of our knowledge of the positions and movements of the heavenly bodies. But the benefits thus gained are only secured by long-continued, patient, and persevering observation on the part of those who sacrifice themselves to this exhausting task. That these observers may accomplish what they aim at and what is expected of them, therefore, it is of the highest importance that they should not be needlessly interrupted in their labors; and hence it must be accounted an advantage, and not an objection, to the location of an observatory, that it is so far secluded as to be withdrawn from the notice of the curious multitude.

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F. A. P. BARNARD,
President of Columbia College, New York.
HENRY A. ROWLAND,
Professor of Physics in the Johns Hopkins University.
CHARLES S. HASTINGS,
Assistant Professor of Physics in the Johns Hopkins University, Baltimore.

No. 9.—*From the chairman of the committee to the Superintendent of the Naval Observatory.*

COLUMBIA COLLEGE,
New York, November 9, 1885.

DEAR SIR: Will you kindly give me information on the following points:

(1) What are the services rendered by the Observatory to the Navy which justify the title *Naval* Observatory? I do not mean here services to *navigation*, because these are beneficial to the commercial no less than to the naval marine.

(2) To what extent does the Superintendent direct the work of the observers?

(3) Is the kind of work done by each professor prescribed to him, or does he select his own kind of work?

(4) Are the professors required to report periodically, or at all, to the Superintendent?

(5) How are the observers held to the faithful discharge of their duties?

(6) By whom are the successive volumes of observations, published by the Observatory, edited?

(7) What amount of their time, *i. e.*, how many nights per week, are the observers required to be on duty?

(8) Is this allotment of time prescribed by the Superintendent, or is it determined by usage?

(9) Is any record kept of the attendance or failure to attend of the observers on the nights when they are due?

By answering these questions you will confer upon me a material favor.

Sincerely yours,

F. A. P. BARNARD,
Chairman.

Commodore GEORGE E. BELKNAP,
Superintendent of the Naval Observatory.

No. 10.—*Reply of the Superintendent to the foregoing.*

UNITED STATES NAVAL OBSERVATORY,
Washington, November 10, 1885.

DEAR SIR: Referring to your letter of the 9th instant, in which you ask certain questions concerning the internal economy of the Observatory, I have the honor to reply as follows:

(1) "What are the services rendered by the Observatory to the Navy which justify the title *Naval* Observatory?"

This question is of a peculiar character, inasmuch as it presupposes the fact of a misnomer, whereas, the real state of the case is that this is the title that the institution has borne during the whole of its existence, save for a very few years, when, owing to a phrase in one of Mr. Bancroft letters, it was called by a name to which it had no right, viz, "National." Two volumes of the Observations (the second and third) were published under this caption, but all the others, each under its proper designation of the Naval Observatory. It is first of all a *naval* institution, its astronomical work being, so far as the *naval service proper* is concerned, of a purely secondary consideration. Its officers, with the exception of three observers and one computer, are commissioned in the Navy, and its work and reputation are the property of the service. Whatever has been done to advance the science of astronomy has been at the earnest request and urging of naval line officers, as there has always been a sincere desire to give all the aid possible to this side of the work; as witness the obtaining of the great equatorial and the new transit circle, which have always been in charge of professors.

What the Observatory does for the Navy, and to do which the service must always have a place, may be seen in the following résumé:

First. It rates all the chronometers that are used in the Navy, the care of which requires the services of two officers, while two more are occupied in keeping the error of the standard clock with which the chronometers are compared.

Second. It tests all chronometers that are offered for sale to the Navy. Its appliances for this work are of the very best, and the result of its competitive trials has been to advance the standard of these important instruments, upon the reliability of which so much depends.

Third. It furnishes to naval stations and to branch hydrographic offices daily noon signals, by means of which the navigators of vessels can, on the eve of leaving port, obtain comparisons with the standard clock. Its appliances for this branch of the work are the best in the country, and no other institution has been able to furnish such accurate signals, nor is it likely that there will ever be a successful rival in this field.

Fourth. It drops time-balls in several ports, by which the same facilities are afforded to navigators. This service is of importance to the mercantile marine also, but it is strictly a function of the *Naval* Observatory, to duplicate the work of which is entirely unnecessary.

Fifth. It furnishes longitude comparisons to naval (and other) parties engaged in such work.

Sixth. It inspects all instruments used in navigation of our vessels of war before they are accepted; and it also overhauls them before they are reissued for service.

Seventh. It employs and trains naval line officers, familiarizing them with astronomical formulæ and work, thus making a reserve from which to draw in case of any outside astronomical work being required.

(2) "To what extent does the Superintendent direct the work of the observers?"

The work to be done by each officer charged with the prosecution of a certain portion is prescribed by the Superintendent after a consultation with a board composed of himself, the senior professor on duty at the Observatory, and the senior line officer next in rank to the Superintendent. The suggestions of the Superintendent of the Nautical Almanac are also not infrequently received and complied with.

(3) "Is the kind of work done by each professor prescribed to him, or does he select his own kind of work?"

This question is answered above.

(4) "Are the professors required to report periodically, or at all, to the Superintendent?"

Each officer charged with the prosecution of certain work is required to report each Monday morning the work that has been done by each and every person of his division.

(5) "How are the observers held to a faithful discharge of their duties?"

It is presupposed that those who are employed here, whether they are civilians or commissioned officers, are sufficiently honorable to do the duty which is required of them, and the report of the officer in charge of the division affords a check upon this. The Superintendents have been loath to apply strict naval discipline to the officers on duty here, whether of the military or civil branch; but if such disciplinary methods and supervision are deemed necessary by the proper authority, they can be readily applied.

(6) "By whom are the successive volumes of observations published by the Observatory edited?"

Each officer whose observations are published reads his own proof, and is responsible for the correctness thereof; the work as a whole (or rather the printing) is under the supervision of Professor Eastman.

(7) "What amount of their time, *i. e.*, how many nights per week, are the observers required to be on duty?"

There are four observers on the transit-circle, whose duty day begins every fourth morning at 9 o'clock, extending to the same hour the following day. Observers who are at their posts at night are not required to be at the Observatory until after noon of the following day. Observers on the equatorials are required to be present every clear night to prosecute their work; but much is left to their discretion for the reason given in the answer to the fifth question. The officers on the time-service with the transit instrument are required to take observations for the clock correction every clear evening, and in the morning when practicable.

(8) "Is any record kept of the attendance or failure to attend of the observers on the nights when they are due?"

No. School-boy requirements are not demanded of gray-headed gentlemen holding naval commissions of rank and responsible station, and looked upon to perform the duties assigned them as observers and computers in the spirit and tenor enjoined and described in said commissions. The personal surveillance indicated in the query is quite foreign to the traditions and usages of this institution and is repugnant to the ideas and methods of naval officers.

In conclusion, your attention is especially invited to the fact that this institution has never been recognized by law in any way except as the "Hydrographical Office," and later as the "*Naval* Observatory." The word "National" as applied to it occurs but once in the various appropriation bills, and that was when money was given for the purchase of the clock invented by Dr. Locke. It is the creation of the line of the Navy, its founder having been Gilliss. If the time has come when the purely scientific side of the institution has outgrown the needs of the naval service, then the converse is true, namely, that the Navy has no need of it, or of the scientific staff. If the so-called scientific men of the country think that the time has come to apply to Congress for money to build a National Observatory, the navy will not stand in their way; only it will take no responsibility for it, and will be glad to see it go to another Department of the Government, and to be under purely civilian control, including professors with civilian appointments instead of naval commissions.

Very respectfully, your obedient servant,

GEO. E. BELKNAP,
Commodore, U. S. N., Superintendent.

Dr. F. A. P. BARNARD,
President of Columbia College, New York.

EXTRACTS FROM LETTERS OF PROF. E. S. HOLDEN.

No. 11. (A).—*From a letter addressed to Prof. S. P. Langley, a member of the committee, under date of August* 10, 1885.

* * * * * * *

I will only speak of two of the questions. First, as to the universal day. I wrote Admiral Franklin a letter, which is printed in an Executive Document, No. 78, Forty-eighth Congress, second session, and which you have seen. I have read everything that has been written on this question, and I see no reason to change the views there expressed. I ask you to read that letter, and I would now wish to add to it the expression of my individual opinion that it is not advisable to consider the change of day any further at present, as it is certain that France and Germany at least will not introduce it for many years, if at all. France will not do it for national reasons. Professors Auwers, Foerster, Tietjen, and Krueger have pronounced against it, and practically control the action of the *Astronomische Gesellschaft*, the *Berliner Jahrbuch*, and the *Astronomische Nachrichten*.

With regard to the second question, relating to an immediate change of site of the United States Naval Observatory, I would say that I am not in favor of a change of its site now or at any time, under the present condition of the improvements to the harbor of Washington. The reasons adduced for a change have always been two, and two only: 1st, the unhealthiness of the site; 2d, the fogs from the river. In the printed report of Admiral Rodgers on this subject, my name is attached to the report in favor of the removal, as well as that of the other professors at the Observatory at that time. When the question was being discussed by us, I told Admiral Rodgers that I wished to add to the report as printed a clause saying that if the harbor of Washington was to be improved as then proposed by Major Twining (and since partly executed), I was not in favor of removal. If it were not to be so improved, I *was* in favor. Admiral Rodgers refused to add this clause, and told me I was at liberty to sign the report as it stood, or to refuse to sign it. As at that time the improvements now in progress had been once rejected by Congress, I signed the report, and now I regret that did so.

It is my opinion that the health of the Observatory site will be made as good as that of the rest of Washington by these improvements, and that the river fogs alone are not a sufficient cause for removal.

They stop observations for the last half of the night during parts of two months of the year. I see no reason why the Observatory site should not be as healthy after the river is improved as the places where I lived for eight years in Washington, viz, 2137 F street, 1923 H street, and 1905 F street. None of my family were ever ill from malaria, and I myself had only two or three very slight attacks. It appears to me that if that portion of the land to be added to the city by the river improvements which lies just south of the present Observatory reservation were to be reserved for observatory purposes (allowing carriage-ways through these parts) the extension of the Observatory grounds to the south would be ample. All meridian instruments could be located on the hill near the present site, and there is sufficient room to the east, and especially to the west. To the south any new equatorials or photographic instruments could find ample space. I would advocate buying the land north of the Observatory reservation from E street to Virginia avenue. This would secure ample room for all extensions necessary, and, if desirable, quarters could be erected for the observers at this place; the cost of this land to be met by selling the "Barber estate," purchased for the Observatory site.

The more this plan is considered the better it will seem. I know of but one class of observations likely to be interfered with should this plan be followed. Low circumpolars would be unsteady at lower culmination. I do not regard this as a sufficient objection to its adoption. We know already that reflection observations would not be disturbed by carriage-ways over the new land to be added at the south, nor on E street.

Should the Observatory desire to go deeply into physical researches, I would advocate a branch observatory in the Sierra Nevada or in the Rocky Mountains, although much may be done at Washington.

You also ask me to give you my opinion as to the question of the "future National Observatory in its broadest form, and specially its relations to the Government Departments." Naturally this is a question upon which I have thought, and I venture to send you a memorandum which touches upon some of the points involved, though of course it leaves others almost equally important untouched.

It is important that the reorganization of the Observatory shall be made, if it is made, according to a plan based on the real interests of astronomical science in the United States, and not on the real or apparent interests of any Department or set of persons. The difficulties in the case which are sought to be obviated ought to be explicitly stated, for two reasons—

1. That they should be plainly understood by Congress.
2. That the basis of the recommendations may be comprehensible.

These difficulties may be best understood by giving a brief history of the Observatory from 1845 to 1884, and here a brief account of the difficulties met with might be given.* I need not repeat this to you who are familiar with them. Among other things, *appointments* of professors of mathematics have not been made in the interest of the Observatory. *Vacancies* at the Observatory have not been filled, but the newly appointed professors have been sent to the Naval Academy, in some cases against the wishes of the Naval Academy. When the law regarding examinations was in force, its spirit has not been carried out, &c.

The Observatory should be called the United States *National* Observatory.

This title accurately describes its functions.

This also was the name of the Washington Observatory from 1845 to 1848.†

The Observatory should be made a bureau of the Interior Department, having direct relations with the Secretary. It is necessary that the Observatory should be a bureau of some one of the Government Departments for fiscal reasons.

As radical changes are necessary, it appears that these can be carried out with more success if the Observatory does not remain under the Navy Department, where a series of precedents has been established, some of which appear to be unwise, notably those relating to the filling of vacancies in the corps of professors of mathematics.

The Government Department under which the work of the Observatory naturally falls is the Interior.

The head of the Department of the Interior should be the source of power at the Observatory. As far as possible he should be guided in his official action by the recommendation of the Board of Visitors and of the Director.

There should be a Board of Visitors of five members. Two of these members should be nominated by the National Academy of Sciences, through its home secretary, to the Secretary of the Interior, who should appoint the persons named. Two of the members should be appointed by the Secretary of the Interior. The four members thus selected should elect one more member. Each member of the Board of Visitors should hold office for five years from the date of appointment in general.

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* I refer you to the New York Nation. November 9, 1882.

† From 1844 to 1856 in the U. S. Statutes.

No. 11 (B).—*From Prof. F. S. Holden to the chairman of the committee, under date of October* 17, 1885.

* * * * * * *

As you ask my opinion on the various points, I shall take the liberty of speaking frankly and fully.

I. The Secretary has asked the opinion of the Academy "as to the expediency of proceeding promptly with the erection of a new Naval Observatory on the site purchased in 1880." I am decidedly of the opinion that this change is unnecessary and unwise (see my letter of August 10, p. 2). I believe the land from E street to Virginia avenue, and between Twenty-third and Twenty-fifth streets, should be bought and the Barber estate sold to pay for it, and the Observatory grounds extended south to the river.

As to whether your committee could properly add any suggestions as to reorganization: if I were a member of the committee my voice would be for answering the Secretary's requisitions exactly; and then for stating that in the view of the committee, other matters were in fact, though perhaps not in form, so closely allied that it felt obliged to cover the whole ground, leaving the Secretary to use it or not, as he might think best.

For example, his question is, "Shall the Observatory be moved?" Suppose the committee to favor a removal *and* a reorganization, it is quite conceivable that it might object to a removal *without* reorganization.

II. I think the Secretary would transmit to Congress any report you might submit.

III. I should, if I were a member of the committee, advocate the plan that seemed best from a scientific point of view, without any fear but that *in the end* it would prevail. In that case, the Academy would have the honor of having early proposed the first solution.

IV. I do not believe that the Observatory owes its tenure of life to the impression that it is essential to the naval service. I have every confidence that Congress would support it liberally for its intrinsic worth. If this is not the case, then it might well be allowed to die. Its present condition is a discredit. But I feel sure that Congress will gladly support any worthy Observatory, or any worthy scientific department of the Government.

The *Government* Observatory certainly has a function which no private (or college) observatory can fulfil. This function is to make, promptly reduce, and promptly publish observations of the principal fixed stars, of the sun, moon, and major planets. The fixed stars are those named fundamental (some 600), and the lists of stars used for zenith telescope latitudes, &c., by the Government surveys of the Coast Survey, Land Office, Geological Survey, &c. The moon is observed at Washington *alone*, owing to the labor. The sun is observed (regularly) at Washington *alone*, and so with the planets. Harvard College, Williams College, Washington, and this Observatory *alone* make regular observations for star positions.

The primary work of the Naval Observatory is and should be regular, systematic, and intelligent meridian observations. These require a transit circle and three observers, and should be promptly published by means of a corps of from six to ten computers.

The work of large equatorials is of primary scientific importance, but of quite a secondary value in the organization of a national observatory. This is at least my view.

There is, however, no question but that Government observatories *must* do work which private establishments cannot undertake. It is simply a matter of income. Dr. Gould, in South America, had, at a government observatory, $40,000 per year, and by immense efforts also did work which *twenty* private observatories on $4,000 a year could not do.

The worst drudgery of the profession must be done at national observatories, where the income is sufficient to provide computers and observers and to divide the labor. * * *

With regard to the universal day, I have spoken in my letter of August 10. The *Astronomische Gesellschaft*, as a whole, seems to be against its present adoption. Certainly Auwers, Kreuger, Foerster, and Tietjen are.

I have expressed my personal opinion very fully and frankly, as your letter seemed to demand; and I ask you to be sure that it is founded (with regard to the Observatory) on a reflection upon the cause of the ills they suffer. I do not believe that any simple remedy, such as appointing any special civilian, will cure those ills. I believe that its whole nature ought to be changed.

No. 11 (C).—*From a letter addressed to the chairman of the committee, under date of October 29, 1885.*

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The condition of the buildings is essentially as stated. But the facts recited show that a new Observatory should be built *there*, not elsewhere. The present site, when improved and enlarged as I suggest, will give ample room for observers' quarters at places where such quarters will not interfere (by smoke, &c.) with observations. * * * I do not believe that the architect's plan of the proposed Naval Observatory, as adopted by Admiral Rodgers and the advisers (myself among them), would receive the unqualified approval of competent astronomers. It would be idle to go into details in this regard, but the best modern observatories—Potsdam, Strasburg, Mount Hamilton, and others—are built on different and, I think, better principles.

The Naval Observatory should be rebuilt so as to make it *by far* the best observatory in America or in the world.

No. 12.—*From the chairman of the committee to Prof. Simon Newcomb.*

COLUMBIA COLLEGE,
New York, November 14, 1885.

Prof. SIMON NEWCOMB,
Superintendent of the American Ephemeris:

DEAR SIR: The committee of the National Academy of Sciences, appointed to consider the question submitted to the Academy by the honorable the Secretary of the Navy in regard to the expediency of proceeding to erect a new Naval Observatory on the site purchased in 1880, desire to obtain from you replies to the following questions, to wit:

(1) How long were you connected with the Naval Observatory as an observer?

(2) During this period did you personally suffer in health from exposure to the malarious influences said to prevail on and about the Observatory site?

(3) Were you aware of the occurrence of such suffering in health on the part of any of your colleagues, or among the members of the family residing in the Observatory building?

(4) Were observations at the Observatory seriously interrupted by fogs rising from the Potomac River?

(5) Do the published volumes of observations made at the Observatory show a steadily continuous prosecution of the kind of work most proper for a national observatory, to wit, the observation of standard stars, of the planets, and of the moon?

(6) Do the same observations give evidence of a consistent direction controlling and co-ordinating the work of the several observers to the accomplishment of the most satisfactory results in the advancement of astronomical science?

(7) Does it appear to you probable that the work of a great astronomical observatory can be carried on advantageously under the direction of a superintendent not himself an experienced astronomer?

Early replies to these questions will be gratefully received by the committee.

Respectfully, yours,

F. A. P. BARNARD,
Chairman.

No. 13.—*Reply of Professor Newcomb to the foregoing.*

WASHINGTON, D. C., *November* 17, 1885.

President F. A. P. BARNARD,
Chairman Committee National Academy of Sciences:

SIR: I have the honor to submit the following answers to the questions propounded me in your communication of November 14. For perspicuity I quote each question:

(1) "How long were you connected with the Naval Observatory as an observer?"

I was attached to the Observatory from 1861 until 1877. But from 1870 until 1873, as well as from 1875 to 1877, I made no regular observations.

(2) "During this period did you personally suffer in health from exposure to the malarious influences said to prevail on or about the Observatory site?"

I cannot say that I personally suffered greatly in health from the cause alluded to. I had occasional malarial attacks, but they were no worse than before my connection with the Observatory.

(3) "Were you aware of the occurrence of such suffering in health on the part of any of your colleagues, or among the members of the family residing in the Observatory building?"

Nearly all my colleagues suffered so much from malaria that I could not doubt that they were exposed to noxious influences. But I was never able to decide to my own entire satisfaction how far these things were due to the site itself, and how far to the defective condition of the building and its surroundings.

(4) "Were observations at the Observatory seriously interrupted by fogs rising from the Potomac River?"

During the spring and autumn, the Observatory was frequently enveloped in fogs, especially after midnight. But I never had any accurate data for deciding whether these fogs were merely local or whether they enveloped the whole district. A decision of this question would require simultaneous observations from some point outside of the city, and these, so far as I am aware, were never made. There is no doubt that the city around the Observatory was frequently enveloped in vapor when the heights north of it were free. At the same time, I sometimes noticed that the Observatory Hill was free from vapor while the region around it was enveloped.

(5) "Do the published volumes of observations made at the Observatory show a steadily continuous prosecution of the kind of work most proper for a national observatory, to wit, the observations of standard stars, of the planets, and of the moon?"

The published volumes do not seem to me to show a steadily continuous prosecution of work. Reviewing these volumes, and considering first the observations of the sun, moon, and planets with the meridian instruments, we find that a valuable series of such observations was commenced in the year 1846. After a couple of years, however, they began gradually to fall off without any apparent reason, and after 1848 became so few and sporadic as to be entirely devoid of value. This state of things continued until September, 1861, when there was a sudden revival of activity in this direction. This continued until 1870, when the number gradually fell off to perhaps one-half that of 1866. This state of things continued until 1881, the date of the last published volume of observations.

During the years 1865–'78, the late Professor Yarnall prepared a valuable catalogue of stars from observations with the older instruments of the Observatory. With this exception, the observations of the fixed stars show the same want of continuity as in the case of the planets.

(6) "Do the same observations give evidence of a consistent direction controlling and co-ordinating the work of the several observers to the accomplishment of the most satisfactory results for the advancement of astronomical science?"

So far as the observations give evidence, no such control or co-ordination has ever existed except in one or two exceptional cases. Out of the numerous instances to illustrate this, I may select one or two.

Since 1875, it would seem that no attempt has been made to determine the right ascension of the standard stars of the Ephemeris. The reason for this I do not officially know, but it seems that the clock used for the transit-circle observations has been running too badly to admit of such determinations. The natural inference would seem to be that there is no authority whose business it is to see that the officer in charge of the instrument is supplied with a clock of the first class.

Previous to 1865, a complete determination of the position of a star or planet required the use of two instruments—the transit, for determining its right ascension, and the mural circle, for determining its declination. Hence in order to make any complete determination of the position, the observers with these instruments should select the same stars or planets. But the observations show that no such concert ever existed. On some days, observations were made with one instrument, and on other days, with the other. Sometimes during a whole year, planets which were observed with the one instrument were wholly neglected with the other. Only in exceptional cases was the same star observed with both instruments during any one year.

(7) "Does it appear to you probable that the work of a great astronomical observatory can be carried on advantageously under the direction of a superintendent not himself an experienced astronomer?"

This depends upon the nature and objects of the establishment. If its working force consisted wholly of eminent astronomers, each of whom was expected to do his own work in his own way, without guidance or direction from any superior authority, then the superintendent would not need to be an astronmer.

But I do not consider that such work is that most appropriate to a national observatory. The latter should principally occupy itself with work requiring the long-continued co-operation of a body of observers working on a well-prepared plan. To suppose that such a body could and would devise and execute such a plan without a managing head thoroughly skilled in the work seems to me contrary to all the business experience of the world in organization. It would, in fact, be like supposing that a body of highly skilled ship-builders could and would build a successful ship without plans and without other direction than that of a controller of expenditure.

Very respectfully, your obedient servant,

SIMON NEWCOMB.

No. 14.—*Remarks of the Superintendent of the Naval Observatory on Professor Newcomb's letter.*

So far as regards the personal experience or opinion of Professor Newcomb as to the existence of effects of malaria, comment is unnecessary, as President Barnard has before him a mass of evidence upon this point.

Attention is drawn to the fact that the Observatory is *naval*, and not *national*, except in so far as the Navy itself is a national organization, it having been created by Congress many years ago as a part of the naval establishment, at the solicitation of naval officers. Its first duties are *naval*, and not *astronomical*, except as the latter bear directly upon the former. It began its existence with a plan of work which was good in itself, as Professor Newcomb states, but which it was impossible to carry out for various reasons, the chief one being the great difficulty in obtaining observers, the corps of professors in the Navy not being able to furnish them in sufficient number. In addition, it may be considered as an ideal state of things where two men of equal age and upon an equal footing (with no military ideas of subordination) can engage in work upon two instruments, with but one clock and one chronograph between them, and have everything go smoothly and without jealousy. The abandonment of the too ambitious programme first laid down was a matter of necessity which it is probable no one regretted more than the Superintendent.

In 1866, the first year of its use, a great effort was made to obtain as many observations as possible with the transit circle. The number of observations of the sun, moon, and planets grew less from year to year, until in 1869 and '70 they fell below the average of the later years. Professor Newcomb was in charge of the transit circle from 1-66 to 1870 most of the time, and, it is understood, claimed to have been made sick by his close attention to observing. While Professor Newcomb may not have been *officially* informed of the reason for omitting the determination of corrections to the places of standard stars, he has been told why the work was discontinued, and the performance of the clock was not the principal reason. The change was made by the officer in charge of the transit circle, with the approval of the Superintendent, and after consultation with other astronomers, because with four observers, with personal equations varying with circumstances, and with the large and constantly increasing list of miscellaneous stars whose places were needed, it was considered impossible to obtain satisfactory results.

So far as the superintendency is concerned, the comparison made by Professor Newcomb between astronomers and ship-builders is illogical. "Skilled ship-builders" *could* make and carry out plans—and astronomers could do the same.

The managing head of the Navy Department is a civilian. The Department, in its various ramifications and wide scope of operations, demands as much intelligence, experience, and knowledge in special lines for its successful administration as is or can be required in astronomical research of whatever character.

The Secretary himself is not a naval expert, but through the knowledge and experience of naval officers, he not only manages and controls all the work and operations of the Department, but advises the President in other matters of general import in the conduct of the General Government.

He is at this moment not only building new ships, but getting up plans for others to be built in the near future; and for such purposes has to depend upon naval and civilian designers and experts to furnish the plans and data to enable him to do the work intelligently.

A like relation may be said to exist between the Superintendent and the different officers—naval and civilian—in their varied duties in carrying on the work of the Observatory; and the work of the Superintendent is largely administrative, as well as directive.

It is also submitted that personal equation cannot be eliminated from the *personnel* of any organization, and thus there is no good reason for believing that a civilian director could manage the affairs of the institution to any better advantage or in any more harmonious degree than now obtains here.

No. 15.—*From Dr. F. M. Gunnell, Surgeoh-General, U. S. N., to the chairman of the committee.*

NAVY DEPARTMENT,
Washington, November 20, 1885.

Dr. F. A. P. BARNARD,
President Columbia College:

DEAR SIR: I have to acknowledge the receipt of your note of the 18th, with inquiry concerning the effect of the filling in of the Potomac flats upon the healthfulness of the site of the Naval Observatory.

I do not think there is any doubt that the filling in of the north bank of the river will be of immediate advantage to the Observatory, situated just above it.

This filling, however, has not yet been extended to the south bank of the Potomac; and for a distance of two miles along that shore in a line southwest from the Observatory, in the direction of the summer winds, there are marshes exposed at low water, which must continue to have some influence on the health of those engaged in making observations at night.

Respectfully, yours,

F. M. GUNNELL.

No. 16.—*From Dr. James E. Morgan to the chairman of the committee.*

WASHINGTON, D. C., *November* 21, 1885.

Prof. F. A. P. BARNARD,
President Columbia College:

DEAR SIR: An answer to your letter of the 18th instant, soliciting my opinion "as to the possible effect of filling in the Potomac flats upon the healthfulness of the site of the National Observatory" has been delayed by my absence from the city. There can be no doubt that the filling of the flats and other improvements to the harbor of Washington now in progress will greatly aid in ridding the vicinity of the Observatory of malaria, and may remove it entirely. It has been stated by positive authority that malaria cannot cross a body of water of any considerable breadth. The Potomac River in front of the Observatory is probably over half a mile wide, and should therefore act as a barrier to the malaria from the Virginia shore, provided the before-mentioned statement is true. Now, if the flats on the Washington side are filled, and the lowlands in the vicinity of the Observatory drained and filled up, it would seem that all cause of malaria would be removed.

In connection with this subject I should mention the fact that the city of Washington during the past summer has been almost entirely exempt from malarial disease. Whether this exemption is due to the partial filling of the flats or to other causes I am unable to state.

Very respectfully, yours,

JAMES E. MORGAN, *M. D.*

No. 17.—*From Dr. J. S. Billings, Assistant Surgeon-General, U. S. A., to the chairman of the committee.*

WASHINGTON, D. C., *November* 18, 1885.

DEAR DOCTOR BARNARD: In accordance with your request, I have investigated the matter of the sanitary prospects of the present Naval Observatory. I have consulted with the engineer in charge of the improvements in the vicinity with regard to what is proposed to be done. I have examined personally the locality of the works actually in progress, and have investigated, so far as available data would permit, the relative prevalence of malarial disease on the Observatory grounds and in the vicinity as compared with the rest of the city. As the result of this investigation, I am of the opinion—

(1) That the malarial influences acting at the Observatory are about the same that they have been for the last ten years, and that they are much stronger there than in other parts of the city. Those who actually do the work of observing, and are at the Observatory nights, and the attendants and watchmen about the place, suffer more or less from the malarial influence. Those who have been there a long time have become, as it were, acclimated, and are less affected than new-comers; but during the months of August, September, and October, it is a matter of ordinary prudence to keep away from the Observatory during the night time.

(2) The work of filling and dredging, which has been going on in this vicinity, does not appear to have had any decided influence as yet upon the healthfulness of the place. The filled flats lying to the south and east of the Observatory present at present most favorable conditions for malarial poisoning, and, unless they are covered with a fresh layer of earth before next summer, it is probable they will give rise to much malaria. These flats, however, have probably never been an important source of malarial affections on the Observatory ground, owing to the direction of the prevailing winds during the autumn months, which is from the southwest and southwest by south, coming from across the extensive marshes on the opposite side of the river, which at this point is comparatively narrow. The contemplated scheme of improvements now being carried out does not include any work on the marshes on the opposite side of the river, and so long as these remain I am of opinion that the Observatory will continue to be a decidedly unhealthy spot.

I do not, therefore, think that the proposed improvements in filling the flats will have any marked effect on the sanitary condition of the Observatory, except perhaps to make it a little more unhealthy than usual for the next two or three years, after which the conditions will probably be about what they are at present.

Very respectfully and truly, yours,

JOHN S. BILLINGS.

President F. A. P. BARNARD.

No. 18.—*From Dr. D. R. Hagner to the chairman of the committee.*

WASHINGTON, D. C., *November* 20, 1885.

DEAR SIR: Yours of the 18th instant has been received. In reply to your inquiry as "to the probable effect of filling in the Potomac flats upon the healthfulness of the site of the Naval Observatory," I suppose you refer to the present location of that building, and not the site of the new Observatory on the heights of Georgetown. Since the advancement of the work on the flats, there has already been a marked change in the prevalence as well as gravity of malarial disease in that section of the city. From the position, however, of the present Observatory, I am inclined to think that unless the Virginia shores and the low grounds in front of the Arlington Cemetery and the so-called Mason's Island are reclaimed, the southern, southwestern, and western winds will still bring the malarial poison to this part of the city. If these improvements were made, I am inclined to think there could be no objection to the present location on the score of health. As far as the present work of reclaiming the flats has gone, everything has been done that could be desired, and it is the earnest hope of all interested in the health and improvement of the National Capital that this noble undertaking may be rapidly pushed to completion. I would state that the proposed site for the new Observatory, in regard to health, is all that could be desired.

Respectfully, yours,

D. R. HAGNER.

No. 19.—*From Dr. William Lee to the chairman of the committee.*

WASHINGTON, D. C., *November* 28, 1885.

President F. A. P. BARNARD,
Columbia College:

DEAR SIR: Your letter dated November 21st is before me. Recognizing the importance of the question regarding the healthfulness of the site of the Naval Observatory, and the high position of the committee which you represent, I was at first undecided as to whether you desired a full and detailed answer to your question or simply my general opinion as a practicing physician. I took steps at once with the first object in view, but soon learned that Dr. Billings, of the United States Army, had already furnished you with information respecting the nature of the work being done at the Observatory site, the character of the soil, vegetation, prevailing winds, temperature, &c.; so I deem it superfluous in me to say anything on those points.

As a practicing physician I would say that my practice for twenty years past had been in the neighborhood of the Observatory. Of late years, I have had comparatively little practice in that locality, but I was at one time physician to the poor, and in that position was very familiar with the locality, which was occupied almost entirely by negroes, and what they call "poor whites."

The locality has always been a center for malarial diseases, and the recent turning up of the soil and deposit of loam in places with rank and decaying vegetation has increased their prevalence. This is my opinion from observation and from conversation with my colleagues, especially the present physician to the poor, Dr. R. A. Neale, who reports his cases to the health officer of the District, Dr. Smith Townsend. That answer applies to the present influence of the filling of the Potomac flats.

The probable influence of the work when completed, assuming that the work is to be done thoroughly and in accordance with sanitary requirements of a suitable subsoil drainage, paving, or asphalting to some extent, and the planting of trees properly, &c., must render the Observatory site less unhealthy. This, I presume, answers your categorical question; but I would say farther that this work once completed, the Observatory site would still be influenced and positively so by the large tracts of marsh land lying on the south shore of the Potomac, from whence come prevailing winds during the malarial season, as being the first high and prominent piece of land to be reached by them. Moreover, much remains to be done to the east and in the immediate neighborhood of the Observatory site (say a couple of squares or less) to reclaim land and build on what now consists of large stagnant pools of water in a clayey soil.

Hoping that I have answered your questions as fully as was expected of me, and being ready to give you any additional information you may desire,

I remain, yours respectfully,

WILLIAM LEE.

No. 20.—*From Dr. T. J. Turner to the chairman of the committee.*

WASHINGTON, D. C., *November* 27, 1885.

President BARNARD,
Columbia College:

DEAR SIR: I have the honor to acknowledge the reception of your note of the 21st instant, requesting my opinion as to the probable effect of the filling in of the Potomac flats, now going on, upon the healthfulness of the site of the Naval Observatory on E street, in this city.

The immediate effect of filling in the flats so as to raise the land level above the tidal influence in the Potomac River will depend upon the amount of vegetable organic matter undergoing retrogressive change that may exist in the soil used to raise such land level above said tidal influence. With decaying vegetable matter associated with heat and moisture, all the factors for the production of the class of diseases known as malarial are likely to occur. The iteration of the above statement has become a maxim in the etiology of such diseases, although the involution of the values of the three terms has not been well made out. The facts upon which this opinion is based are the common property of my profession, and can be found in most of the treatises upon malarial fever since Lancisi's time.

I am of opinion, therefore, that the immediate effect would be an increase in the malarial diseases of the said locality, the more especially as the prevalent winds (S. W.) would carry the "malaria" directly over the Observatory.

As to the remote effect of filling up the flats, my own observations lead me to state that the influence is in the direction of a more healthful condition.

Time is to be considered in this, and the lesser or greater length of time necessary to arrive at such condition will depend of course upon the slowness or rapidity of the destruction of the organic matter in the soil used in the filling up. I use the term "destruction" in the sense of molecular change in the organic structures.

Briefly, then, for I have no desire to extend this note beyond the facts and opinions that I have—

(1) The immediate effect will, in all probability, be an increase in the malarial diseases of the locality.

(2) The remote effect will, in like manner, be a decrease in such malarial diseases, and consequently, a more healthy condition of the Observatory attachés.

I have not here considered this matter from any other stand point than that presented in your note. Other sanitary considerations being eliminated, much of the reasoning upon the facts of the origin of malarial diseases has been after the "*post hoc, ergo propter hoc*" variety, but such as it is it has been accepted.

I am, Professor Barnard, with great respect, very truly yours,

T. J. TURNER,
Medical Director, U. S. A.

APPENDIX E.

REPORT ON THE TARIFF CLASSIFICATION OF WOOL.

[CORRESPONDENCE.]

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., February 4, 1886.

SIR: I have the honor to transmit to you herewith a report on the tariff classification of wool, made by a committee of the National Academy of Sciences, in compliance with the request contained in your communication dated December 3, 1885.

I return also, as requested, the sample sent with that communication.

Very respectfully,

O. C. MARSH,
President National Academy of Sciences.

The SECRETARY OF THE TREASURY.

TREASURY DEPARTMENT, OFFICE OF THE SECRETARY,
Washington, D. C., December 3, 1885.

SIR: A question having arisen on an appeal from the decision of the collector of customs at New York in regard to whether certain wool imported into that port has been scoured or simply washed, I transmit under another cover a sample of such wool, and will thank you to submit it to the National Academy of Sciences, for examination (microscopical or otherwise) for the purpose of enabling this Department to definitely determine such question.

I will thank you to inform me of the result of such examination at as early a day as practicable.

If possible please cause the sample to be returned.

Very respectfully,

D. MANNING,
Secretary.

Prof. O. C. MARSH,
President National Academy of Sciences.

YALE COLLEGE, NEW HAVEN, CONN.,
December 16, 1885.

SIR: I have the honor to acknowledge the receipt, through Professor Baird, of your communication of the 3d instant, submitting to the National Academy of Sciences the question whether certain imported wool, a sample of which was also received, had been scoured or simply washed.

I have placed the matter in the hands of a special committee of the Academy, consisting of—

Prof. C. F. Chandler, Columbia College, New York City, *Chairman.*
Prof. W. H. Brewer, Yale College, New Haven, Conn.
Prof. Henry Morton, Stevens Institute, Hoboken, N. J.

These gentlemen will give the subject careful consideration, and report at an early day.

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

The Hon. SECRETARY OF THE TREASURY.

NEW YORK, *January* 30, 1886.

SIR: I have the honor to submit to you herewith the report of the committee of the Academy, appointed by you to consider the question in regard to the classification of wool, submitted to you by the honorable Secretary of the Treasury.

Very respectfully, your obedient servant,

C. F. CHANDLER,
Chairman.

Prof. O. C. MARSH,
President National Academy of Sciences.

REPORT.

The committee of the National Academy of Sciences has carefully examined and analyzed the sample of wool submitted by the honorable Secretary of the Treasury. The sample was marked "Appeal 7513^{m}, official sample Donskoi wool, ex European, September 7, 1885," and with the name of the firm importing it.

The physical properties and the chemical composition of this wool, considered in connection with the peculiar character of the wool fiber itself, have led the committee to decide unanimously that this wool is *simply washed wool*, and that it is not *scoured wool.* If there could be any doubt as to the character of this wool in this respect, it would be not as between washed and scoured wool, but between unwashed and washed wool.

In accordance with the suggestion that the report be full and comprehensive, we submit herewith:

I. A general statement relating to wools.

II. Examination and analyses of the samples of wool submitted, and of other wools procured by the committee.

III. Analyses of wools published by others.

IV. Investigations on the composition of the fleece of merino and coarse-wooled breeds of sheep, made by W. Chludsinsky in the laboratory of the Agricultural Experiment Station at New Alexandria in the Government of Lublin, Russia, 1885.

V. Conclusion as to classification.

All which is respectfully submitted.

C. F. CHANDLER,
Chairman.
WM. H. BREWER,
HENRY MORTON,
Committee.

I.—*A GENERAL STATEMENT RELATING TO WOOLS.*

Commercial wool is a very variable product. Its sorts and kinds differ in each and every physical character; hence any classification founded on such characters, and into which all kinds and grades will readily fall, must be very difficult, and in fact is practically impossible. Any discussion of a satisfactory classification must take into account the character of the differences and also their cause.

Wool is produced by several species of animals, but inasmuch as the vast bulk of commercial wool is that of sheep, sheep's wool is here especially discussed, unless otherwise stated.

A "*fleece*" of sheep's wool is the whole of the coat which is taken from the animal at one shearing. With some breeds, this is so matted and coherent that it may easily be taken off in one piece; with other breeds, it is very much less coherent, and is so torn in the shearing and handling that it comes into trade as a bundle of more or less detached fragments.

Most commercial wool represents one year's growth, but in some countries, there are two shearings per year, particularly of those breeds producing carding or felting wools. When from animals less than nine months old, it is known in market as "lambs' wool."

There is also a general distinction between the wool sheared, and which is known as "*live*" wool, and that taken from pelts, which is known as "pulled" or "dead" wool. This last represents various ages and lengths of growth, and usually comes into market sorted into various grades, depending on length of staple, fineness, purity, and other qualities.

Typical wool differs somewhat from fur and hair in its microscopic structure, but not essentially in its chemical composition or mode of growth. In a general way, we may say that wool is modified hair, that the fibers do not taper so much from base to tip, that they are more wavy, that they are more elastic under a pulling strain, and that the scales or so-called serratures which roughen the surface are different in shape, but each of these characters of wool passes into those of hair by insensible gradations, from that in the most typical wool at one end of the scale to the most characteristic hair at the other end.

Most, if not indeed all, wool-producing animals have both hair and wool, and with sheep, except in the most highly improved breeds, both grow intermingled in the same fleece. Much less than a century ago, this was considered a matter of course, and was true of all the more important breeds, even the merino, and contemporary publications on both the breeding of sheep and on the working of the wool had much to say as to the amount of "*jarre*" (as this coarse hair found in the fleece is called) in the fleece, and the best means of getting rid of it. Hair is produced most abundantly on the thighs and lower part of the neck. It has been practically eliminated by breeding from the more improved breeds, but in the ruder and neglected breeds, particularly those of Eastern Europe and Western Asia, there is a tendency of the wool to pass into hair, and a part of each fleece, so far as texture and properties are concerned, is practically hair.

Chemically considered, wool is a nitrogenous compound, similar to nails and horn in actual chemical composition. It is very hygroscopic, absorbing some 10 to 20 per cent. of its weight of water with great avidity, and holding a part of this water with very great tenacity, making it difficult to thoroughly and absolutely dry it. It is also absorbative of grease, oil, and various other animal substances.

Its growth is always accompanied with other secretions, which issue from the skin along with it and lubricate it, rendering it more or less "yolky" and giving it its peculiar and characteristic odor. These secretions differ enormously in amount between the different breeds, and vary greatly in character. Their chemical history will be considered later. Here it is only sufficient to say that besides the oil which accompanies all wool there is a complicated mixture of several chemical substances, called together "*yolk*" or gum (or sometimes "*Suint*," the French name, German "*Fettschweiss*," and "*Wollschweiss*"), and which constitute a large percentage of the unwashed merino wool. In extreme cases, and with certain fine-wooled breeds, these secretions constitute upwards of 60 per cent. of the unwashed fleece, diminishing in quantity as the fibers become coarser and the staple longer, and as the wool passes from the carding to the combing varieties, reaching its minimum in certain coarse-wooled native breeds. This "yolk" is chemically a sort of natural soap, and is more or less soluble in water. In certain merino breeds, it is bred for, and thus its quantity has been relatively increased, and, when abundant, dirt and dust are more apt to cling to the wool, thus diminishing still further the percentage of actual wool-fiber.

Sheep have been domesticated and bred from the remotest antiquity, and the species, originally plastic, has greatly changed in character. In the many centuries this artificial breeding has been going on, with the widely different conditions of climate, soil, topography, feed and care under which the flocks have been bred, and the different wants they have been made to supply, hundreds of varieties have originated, which have been further differentiated and specialized by the breeder's art, until now these domestic breeds differ among themselves as widely and yield as great a variety of production as if produced by many originally unlike species.

As the wool is grown for a much greater variety of uses than the carcass, it has been made to vary the most, until now we have it of every length, from less than an inch to more than a foot, varying in the fineness of its fibers from less than 1-1800 of an inch in diameter to more than 1-400, or from that of very fine fur to that of coarse hair. It differs in the evenness of its fiber, in the shape, projection, and sharpness of its scales or "serratures," and in the number of them in a given length of fiber. It differs in the strength of fiber, in the elasticity under a pulling strain, its elasticity under torsion and bending, in flexibility, in harshness or softness to the touch, in its felting, fulling, carding, combing, and spinning qualities, in the quantity and chemical character of the secretions which naturally lubricate it, in its color and luster, in its behavior towards dyes and mordants, and so on through each and every character wherein an organic production can vary, and particularly in those characters on which its commercial value depends.

This is not merely a difference between the production of different breeds, but all of those characters which modify the commercial values of wools vary on the different parts of the same animal. This difference was previously greater than now. In most of the works on sheep-breeding published more than thirty years ago, particularly of the fine wooled breeds, there are cuts by which the animal or its fleece is mapped out into the portion producing the different qualities. The most common division of each fleece was into four grades, depending on length, on evenness of fiber, on fineness of staple, and on its elasticity. The differences were fully as great in coarse-wooled fleeces, but as the wool was used for the manufacture of less expensive fabrics, less point was made of this lack of uniformity of growth. And less is made now, partly owing to breeders producing animals with a more uniform fleece, partly to changes in methods of manufacture, and partly to changes in the fashion of prevailing fabrics.

The conditions of climate, soil, feed, water, and topography, under which the flocks are kept, also affect each of these qualities of the wool. It has been known from remote times that the pasture and climate affect the harshness and softness of wools to the touch, as well as their luster, and it is now known that it affects also their behavior towards dyes. A flock which produces a certain quality of wool in one place will not always produce precisely the same quality when taken to another. This is of more commercial significance with the carding than with the combing wools, but that the quality of the wool varies with the locality is well enough known to manufacturers, and is conceded by most breeders. Moreover, pastures that vary greatly at different times of the year affect the wool in other ways, but chiefly in making the fibers of unequal fineness in different portions of their length, and decreasing their strength at certain points of growth.

Again, the health of the animal affects the quality as well as the quantity of the wool and its accompanying secretions, and dead wool has different properties from fleece wool. This is sometimes a difference in luster; at others it shows itself in different behavior towards dyes and mordants; at others it affects the purity of the fleece, and so on through its several characters.

Manufacturers roughly range all wools into two great classes, according to the nature of the fabrics they enter into, the "*felting*" wools and the "*worsted*" wools. From the methods of treatment, the former are also called *carding* wools and the latter *combing* wools, and the agricultural terms for the same are *fine* and *coarse* wools, also *short* and *long* wools—that is, the felting wools as a class are worked by carding; they are of shorter staple, and finer fiber.

The felting quality is dependent in part on the relative number and sharpness of the "serrations," and in part on the closeness of the so-called "spirals," which are in reality a certain wave-like curving of the fibers in the staple. The growth of this class of wools is in a measure correlated with the production of yolk and oil, and these ingredients are found in vastly larger proportion in the best carding wools than in any of the combing wools. The merino breed is the basis of production, and the finer sorts of the wool are used in broadcloths and cassimeres, the grades going into numerous kinds of fabrics. The breeds producing these wools are grown specially for wool, and but very rarely indeed for mutton or other uses.

The worsted wools as a class are coarser and longer, some of them attaining great length, the fibers are smoother—that is, the "serrations" are relatively very much fewer and less sharp—the fibers are straighter, and its growth is accompanied with very much less yolk. So the wool is dryer, and the typical sorts are prepared by combing rather than by carding. This distinction, however, is less marked than the others, as manufacturers have devised machines by which many wools are now carded which were formerly combed. A vast number of breeds produce these wools. All the mutton breeds of sheep are coarse-wooled, and in some localities, the wool is but a secondary product; hence there is a much wider range of character in the coarse commercial wools than in finer felting ones.

Many of these longer combing wools are accompanied in the fleece with a shorter kind, found nearer the skin, and having different characters, and which, when combed out, are known in the market as *noils*, and have their special uses in the manufactures.

Wool coming into market just as it grew is known in this country as *unwashed* wool; in England (particularly the fine wools), as wool "in the grease."

It is the common practice with sheep growers in most countries before shearing, to wash the sheep in running water of natural temperature. The yolk is partly soluble in cold water (more in hot), and if this washing is thorough, a part also of the oil and the attached dirt is removed, the oil being somewhat soluble in a solution of the yolk, or else it and other dirt are mechanically removed with the soapy emulsion. No matter how poorly this washing by the wool-grower may be done, or how much impurity may be left in the fleece, it is known in the market as *washed* wool.

But most wool requires further cleaning before it is spun or felted. After this process, which is done by the buyer (usually by the manufacturer) with soap or chemicals, and usually in hot water, it is known as *scoured* wool.

Dead wools are sometimes washed on the pelts, at others removed after the pelts have been treated with some chemical which loosens the wool, and makes it come off easier. These, and dead wools pulled from the carcasses of sheep which have died by disease, are sometimes treated with hot water, and then come into market more nearly cleansed than if merely "washed," and less so than if *scoured*, as this term is usually applied by manufacturers. The treatment of dead wools by hot water as a sanitary measure is somewhat practiced, a peculiarly malignant disease known as wool-sorter's disease originating in pelts or wool infected with anthrax. Wool so treated has some of the qualities of scoured wool, both chemically and mechanically, without being cleaned in the manufacturer's meaning of the term.

But wool as cleansed by the manufacturers is not usually entirely free from oily secretions. In some processes in the manufacture, the material works better with a certain proportion of oil left in it, and thus certain "cleansed" wools (usually the finer or felting kinds) have actually more of the natural secretions left in them than is found at all in certain coarser wools, even in their raw state. So, that while washing and scouring and cleansing are essentially chemical processes, yet a chemical analysis alone will not determine whether wool has been scoured or not. The chemical analyses appended abundantly show this, so that in any commercial classification, the origin, texture, and uses must be taken into account.

Thus far we have considered only those differences which depend chiefly on the animal itself and its feed and locality, and where the impurities of the fleece are chemical, natural to the growth, and may be determined by chemical methods. But there is also a great variety of what may be called accidental and mechanical impurities, of which there is a great number. Sometimes grease in some form is applied to the wool during its growth on the sheep, either to promote its growth or improve its appearance. This is often the case with fine-wooled sheep. Tar, paint, lampblack, and other coloring matters are used to mark the sheep, and this goes into the wool. Various solutions and washes are used to "dip" the sheep, to kill parasites, or cure the scab or other diseases, and so on.

In addition to these are the accidental mechanical impurities; dust sticks to the fleece, hay seed, chaff, and other bits of dried and broken vegetable matter adhere, or get incorporated in it, and in some countries, burrs of various kinds get in, for the separation of which special machinery is devised, but all of which affect the purity and commercial value of wools.

The fleece is also often, if not indeed usually, contaminated in certain parts by the excrements of the sheep. These, with certain other portions from the legs, are sometimes separated and sold separately as "tag-locks," but more often come into the trade as a part of the fleece, to be sorted later.

II.—*EXAMINATION AND ANALYSIS OF THE SAMPLE OF WOOL SUBMITTED.*

The sample was marked "Appeal 7513^m. Official sample Donskoi wool; ex European. Sept. 7, 1885." [Name of firm.]

This wool is a long, coarse, very dry, harsh wool, to which dirt does not readily adhere, and which even on the sheep, before it is washed at all, holds the smallest amounts of fat and yolk. The wool was examined under the microscope, and all its physical properties were carefully noted. It was greasy to the feel and had the strong odor of the sheep.

A carefully averaged sample of 100 grammes, about 4 ounces, was picked over by hand, with the aid of cards, and 5.990 grammes, or 5.990 per cent. of mechanical impurities were separated, consisting of straw, seeds, sand, &c.

Two samples, A and B, as fairly averaged as possible, were submitted to analysis, as follows: (1) Moisture was determined by drying to constant weight at 105° C. or 221° F. (2) The fat, &c., was extracted from the dried wool by means of ether in Soxlet's extraction apparatus. (3) The wool freed from fat and other matters soluble in ether was washed with lukewarm distilled water. (4) When pure water ceased to remove anything from the wool, the washing was continued with a lukewarm solution of sodium carbonate containing one-half of one per cent. of carbonate. (5) The wool was then washed with water, and finally with water containing a few drops of hydrochloric acid, finally dried at 105° C., and weighed.

The results were as follows:

Analysis of wool submitted by the Treasury Department.

	Sample A.	Sample B.	Average.
Moisture at 221° F	8.597	8.458	8.528
Fat, &c., extracted by ether	1.736	2.282	2.009
Matter extracted by water	0.926	1.231	1.079
Matter extracted by ½ per cent. solution carb. soda	2.200	1.499	1.849
Mechanical impurities	5.990	5.990	5.990
Pure wool fiber	80.551	80.540	80.545
	100.000	100.000	100.000

Analyses of wools collected by the committee.

	1.	2.	3.	4.	5.	6.	7.
Moisture at 221° F	7.24	7.78	....	6.63	6.38	6.83	6.96
Fat, &c., extracted by ether	5.97	3.49	2.33	16.36	13.27	10.04	6.66
Matter extracted by water	0.90	2.00	4.09	2.99	2.86	1.35	2.22
Matter extracted by ½ per cent. soluble carb. soda	1.42	1.50	....	0.59	1.52	2.02	0.84
Wool fiber and mechanical impurities	84.47	85.23	81.07	73.43	75.97	79.76	83.32
	100.00	100.00	....	100.00	100.00	100.00	100.00

Nos. 1, 2, and 3 were obtained from the Agricultural Department at Washington, through the kindness of Mr. Clifford Richardson. They were labelled as follows:

No. 1. Wool for flannel; scoured; Ware, Mass.

No. 2. Foreign washed Donskoi, Lowell, Mass.

No. 3. Foreign washed Donskoi, rewashed at mill, Lowell, Mass.

Nos. 4, 5, 6, and 7 were obtained from Mr. P. S. Connor, superintendent of the pulling establishment of D. Harrington & Co., on First avenue, in New York. They are wools which were washed on the pelt, in cold sea water, pumped from the East River. The washing is very quickly accomplished, the coarse pelts are simply dipped into an overflowing vat of water, into which a 2-inch stream constantly runs. One man washes 800 in a day. The finer pelts are washed on a machine in the same water.

The samples were marked:

No. 4. B super wool, washed.

No. 5. Fine combing wool, washed.

No. 6. De Laine wool, washed.

No. 7. Regular combing wool, washed.

Samples 2 and 3 were of very much the same quality as the wool submitted to the committee; all the other samples examined were of an entirely different character.

After analyzing these samples of wool, comparing the wools with each other, and studying the different portions of the same sample, the committee became convinced: (1) That analytical results obtained from wools of different grades are of no value in determining whether wool has been washed or scoured. (2) That analytical results obtained from samples of wool of the same grade cannot be made to furnish an absolute percentage basis for determining this question, because it is impossible to select a fair average sample for analysis, only 5 grams or 76 grains being used with advantage in each case, and because "washing" differs in degree, and may be more or less thorough, according as it is performed on the sheep, on the pelt, in running water, in tubs, in warm, or in cold water.

The conclusions reached with regard to this sample are based on its physical properties, and its chemical and mechanical composition by bringing it into comparison with wool of the same grade from the same locality, in its natural state and after it had been washed, information for these comparisons being derived from the observations of the committee on the samples procured and upon the published results of other investigators, some of which are presented in this report.

III.—*ANALYSES OF WOOLS PUBLISHED BY OTHERS.*

COMPOSITION OF YOLK OR SUINT.

Chevreul gives the following list of substances which he found in suint, in a paper read before the Academy of Sciences on May 4, 1857. [Comptes rendus, XLIV, 887.] The 30th constituent was announced in a paper read May 7, 1866. [Comptes rendus, LXII, 1015.]

1. Water,
2. Ammonia,
3. Carbonic acid,
4. Aroma of the sheep,
5. Aroma y,
6. Phocenic acid (valeric),
7. Volatile acid x,
8. Stearine,
9. Elairine,
10. A crystallizable fatty body,
11. Potassic stearate,
12. Potassic elairate,
13. Potassic phocenate (valerate),
14. Potassic salt of the volatile acid x,
15. Potassic salt of a colorless crystallizable acid,
16. Potassic salt of an orange uncrystallizable acid,
17. Potassic salt of a sulpho-azotized acid,
18. An insoluble sulpho-azotized acid,
19. Potassic carbonate,
20. Potassic sulphate,
21. Potassic silicate,
22. Potassic chloride,
23. Calcic oxalate,
24. Calcic phosphate,
25. Ammonio-magnesic phosphate,
26. Calcic carbonate,
27. Ferric oxide,
28. Manganic oxide,
29. Cupric oxide,
30. Elegic acid.

Stockhardt found that the percentage of yolk differed in the wool from different parts of the sheep. [Chem. Ackersmann, 1861, page 58.] His figures are as follows:

Percentage of yolk in the dry wool.

Articles.	Merino.	Southdown Merino.	Southdown Frank.
Sides	40.1	28.9	12.6
Flanks	32.6	17.2	10.1
Withers	39.8	17.5	2.0
Belly	41.6	25.8	5.9
Root of tail	42.4	24.4	13.2

ANALYSES OF WASHED WOOL.

[Elsner and Gronow, annal. d. Landwirthsch. Wochenblatt, 1865, No. 16.]

Combing wools.

	Pure wool fiber.	Yolk.
Leicester, from Canada	81.5	18.5
Cordova, from South America	81.8	18.2
East Indian	89.2	12.8
Donskoi winter wool	82.4	17.6
Do	89.5	10.5
Donskoi summer wool	85.4	14.6
Crimea	92.9	7.1
Chersonesus	67.1	32.9
Bessarabia winter wool	97.6	2.4
Lincolnshire	67.4	32.6

Composition of unwashed wool according to Reich and Ulbricht.

[Published in Ann. der Landwirthsch. in dem Preuss. Staaten Monatsbl. 1867, vol. 49, 122.]

Number.	Kinds of wool.	Pure wool fiber.	Yolk.
1	Electoral negretti buck	27.81	72.19
2	Electoral negretti buck	23.39	76.61
3	Four-year old French merino buck	37.77	62.23
4	Pure Rambouillett yearling buck	31.72	68.28
5	Rambouillett and electoral Negretti yearling buck	28.26	71.74
6	Rambouillett ewe	31.33	68.67
7	Lincoln merino yearling	44.61	55.39
8	Pure Lincoln sheep, five year old	55.82	44.18

Composition of the yolk.

	1.	2.	3.	4.	5.	6.	7.	8.
Moisture	12.70	11.80	12.80	14.55	15.10	13.85	16.00	15.40
Soluble in ether	22.85	28.18	23.35	13.03	12.69	20.36	9.93	8.85
Containing:								
Fatty acids	7.750	9.880	7.400	?	2.094	2.593	1.550	2.217
Unsaponifiable fat.	12.257	15.107	14.601	10.557	9.714	16.530	7.536	5.789
Other substances soluble in ether	2.873	3.193	1.348	....	0.882	1.237	0.844	0.844
Soluble in alcohol	7.16	5.22	4.88	4.40	5.70	7.70	4.25	3.51
Containing:								
Fatty acids	2.300	1.400	1.630	1.460	2.156	4.149	1.565	1.670
Potassa	1.062	0.711	0.693	0.734	0.990	0.756	0.352	0.558
Potassium chloride	0.524	0.684	0.586	0.551	0.673	0.873	1.062	0.581
Soda	0.073	0.046	0.033	0.032	0.053	0.085	0.059	0.029
Other substances soluble in alcohol	3.172	2.374	1.930	1.627	1.823	1.836	1.178	0.668
Soluble in water	11.66	10.64	8.69	......	......	......	......	......
Containing:								
Potassa	3.307	2.762	2.131	3.911	2.920	3.642	4.046	2.520
Soda	0.227	0.117	0.199	0.246	0.309	0.137	0.247	0.122
Lime	0.129	0.056	0.116	0.200	0.160	0.120	0.156	0.080
Magnesia	0.050	0.021	0.061	0.065	1.090	0.086	0.100	0.075
Phosphoric acid	0.072	0.037	0.092	0.109	0.141	0.064	0.142	0.102
Sulphuric acid	0.059	0.053	?	0.085	0.101	0.065	0.081	0.055
Silica	0.027	?	0.012	0.031	0.026	0.024	0.025	0.022
Carbonic acid in carbonates	......	......	......	0.107	0.099	0.070	0.117	0.088
Carbonic acid produced by combustion	......	1.257	0.896	......	......		......	......
Total ash	5.842	......	......	6.743	5.234	5.566	6.809	4.260
Soluble in acid water, containing:								
Calcic carbonate	0.594	......	......	0.311	0.274	0.195	0.179	0.132
Magnesia	0.031	0.028	0.065	0.028	0.023	0.030	0.014	0.019
Phosphoric acid	0.014	0.028	0.019	trace	0.004	0.011	0.008	0.005
Dirt	17.17	20.72	12.50	29.22	32.72	20.96	18.21	12.01
Pure wool fiber	27.81	23.39	37.77	31.72	28.26	31.33	44.61	55.82

ANALYSES OF UNWASHED WOOL.

[Made by M. Maercker and E. Schulze in the laboratory of the experimental station at Weende. Published in Erdmann's Journal für praktische Chemie, vol. 108, p. 200, 1869.]

In 100 parts of air-dried wool are contained—

	Country sheep.					Pure blooded Rambouillet.		
	1.	2.	3.	4.	5.	6.	7.	8.
Moisture	23.48	16.90	16.92	18.86	17.45	12.28	10.83	11.62
Fat (pure)	7.17	....	....	....	....	14.66	....	....
In successive treatment:								
Soluble in water	21.13	20.73	22.98	21.78	22.26	21.83	20.50	22.49
Soluble in alcohol	0.35	....	....	....	....	0.55	....	....
Soluble in dilute hydrochloric acid	1.45	....	....	....	....	5.64	....	....
Soluble in alcohol and ether	0.29	....	....	....	....	0.57	....	....
Pure wool fiber	43.20	50.08	43.50	46.54	42.28	20.83	32 78	29.51
Dirt	2.93	....	....	....	....	23.64	....	....
	100.00	....	....	....	....	100.00	....	....

Numbers 1 to 5 were from ordinary country sheep, which were used for experiment on fodder, and were kept in closed spaces, free from dirt, and mostly without straw. Hence their fleeces were very free from dirt.

No. 6 was a mixed sample of wool.
No. 7 was from a Rambouillet buck.
No. 8 was from a Rambouillet ewe.

WOOL WITH A PITCHY YOLK.

[G. Schulze and J. Barbieri, J. f. Landwirthschaft, 1879, 125.]

Authors state that the ordinary yolk or suint of sheep consists chiefly of cholesterin, isocholesterin, and fatty acids. But occasionally there is found a pitchy yolk which it is very difficult to remove by washing. They present an analysis of a fleece containing such a yolk. The percentage of fat is two or three times larger than usual, while the percentage of substances soluble in water is as much smaller. This yolk is also remarkable in being entirely free from the usual potash soaps.

Some of the authorities which have been consulted.

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1879. E. Schulze und J. Barbieri. J. f. Landwirthschaft, 125.
1884. W. S. B. McLaren. Spinning, woollen and worsted. 12mo. 252 pp. London.
1885. W. Chludsinsky. Die landwirthschaftlichen Versuchs-Stationen, xxxii, 115.

IV.—*INVESTIGATIONS ON THE COMPOSITION OF THE FLEECE OF MERINO AND COARSE-WOOLED BREEDS OF SHEEP.*

By W. Chludsinsky,

Docent at the Agricultural Institute of New Alexandria, Government of Lublin, in Russia.

[Die landwirthschaftlichen Versuchs—Stationen, Bd. XXXII, p. 115. Berlin, 1885.]

Wool in the fleece has quite a complicated composition. Besides the wool substance and its attendant hygroscopic moisture, which is never absent, the fleece of sheep contains the so-called "yolk," a mixture of the various secretions of the skin (chiefly the fat and in small quantity, the perspiration). In those merino sheep covered with delicate wool whose fleece contains the greatest amount of fat, the perspiration glands are the least developed; on the other hand, these glands are more fully developed in the rough-fleeced sheep, whose wool is not rich in fat. Since the yolk possesses a consistence more or less viscous, all substances which come in contact with the wool adhere to it more or less, and consequently form a part of its composition.

Thick-growing wool, with excess of yolk in its mass, retains not only the "scum" (dead scales of the skin), but also the earthy matter and food refuse which falls upon it. Finally, the ends of the fibers of the wool get soiled with the excrement, which, becoming more or less smeared over the surface of the fleece, is eventually rolled into balls or pellets.

Since only the wool substance contained in the fleece has a technical application, it would appear at first sight that for the right appraisement of the commercial fleece, it is only important to determine its quantity; but the determination of the wool substance is not sufficient for the estimation of the actual commercial value of the fleece. A wool analysis may determine in the interest of the wool producer, as well as that of the buyer and manufacturer, not only the percentage of wool substance in the fleece, but also the amount of the other ingredients.

What constituents of the fleece are of interest to the grower and the manufacturer in order to estimate its correct value will be evident when we enumerate all those operations to which the fleece is subjected before we obtain from it the material as ultimately used by the manufacturer.

Before the fleece is shorn, it is washed by bathing the sheep in water of 63° to 70° Fahr. By this washing, a portion of the yolk which is soluble in water at the above temperature, food refuse, pasty excrement, and earthy matter in the form of dust are removed. The sheep is now shorn; from the fleece the waste is sorted out, and the fleece is then sold. In such a fleece, there is still an ingredient useless to the manufacturer, namely, the portion of animal secretions insoluble in cold water.

For its removal, the manufacturer subjects the fleece to a second washing, in which he applies hot water, soap, alkalies, carbon disulphide, &c.

Since the producer or wool merchant sells the wool after the first washing, it is evident that he ought to know how much is thus washed out, for when he knows this loss and also knows the weight of the unwashed fleece of his sheep, he can easily determine how much material he produces for the manufacturer. Again, the manufacturer is interested to know how much insoluble fat and how much wool substance is in the washed fleece which he buys.

From what has been said, we see that a fleece analysis in the interest of the wool producer and of the manufacturer must determine the following constituents:

Impurities (dust, food refuse, excrement) and the non-soluble part of the animal secretions. We designate all these substances collectively by the letter A; the secretions insoluble in cold water by the letter B.

The remainder is the pure wool substance and its attendant hygroscopic moisture. Finally, we obtain a complete idea of the composition of the fleece when we, in addition to the above-described groups A and B, designate the hygroscopic moisture by C and the pure wool fiber by D.

If we would sell the wool according to the conventional custom as unwashed fleece, the determination of the above-designated constituents would perfectly answer the object of the technical appraisement for the seller and for the buyer, inasmuch as the former would know how much pure wool he sold in the fleece, and the latter would know how much he bought in a given weight of fleece.

I will now describe in turn all those manipulations which must be applied in wool analysis that the above-mentioned fleece ingredients may be determined.

The selection of the sample.—If the percentage of impurities and fats were the same in all parts of the fleece, we could take for analysis a sample from any portion. However, investigation shows that different parts of the body produce different amounts of secretion, as the following table (from *Gohren*, *Naturgesetze der Fütterung*) shows:

Percentage of yolk and fat in wool referred to the weight of the fleece.

	Merino sheep.	Southdown Merino sheep.
Side	40.1	28.9
Shoulder-blade	32.6	17.2
Head	39.8	17.5
Belly	41.6	25.8
Root of the tail	42.4	24.4

Secondly, it is known that dust and food refuse contaminate principally the fleece of the upper part of the body, neck, head, and back; but the thighs are soiled mainly by excrement. It is evident, then, that when we wish to obtain a sample which shall present the mean composition of the fleece, this sample must be made up of nearly equal weights of samples, to be taken as follows: From the right and left sides (two), from the right and left hind legs (two), one from the rump, one from the back, and one from the belly (seven in all). These samples must be thoroughly mixed. Ten grams of this mixture are sufficient for a wool analysis.

The sample so obtained is divided in halves. One-half will serve for the determination of the hygroscopic moisture. Of this we will speak later. The other half is for the estimation of the Groups A and B.

For the determination of the Group A, the sample is weighed, the dust is blown and shaken out, and the wool thus freed from mechanical mixture is then washed. The water must be at the temperature of 63° to 70° Fahr., in order to imitate the washing on the sheep. In the laboratory, I use distilled water of the above temperature. Before the wool undergoes a washing with mechanical manipulation, it must be soaked about two hours in the water. The balls of excrement are thereby softened, without which they cannot be washed out. The more greasy the wool, the more dirty the fleece is; the more excrement there is on the wool, the more indispensable does such a preliminary soaking become. The merino wools and the fine sorts of English breeds (Southdown and Oxfordshiredown) require longer soaking than others. When the balls are softened, the wool must be kneaded and rinsed in a vessel of water, the water being changed repeatedly until the wool ceases to discolor it. Usually, the first-wash water is very dirty, and has a turbid brown or chocolate color; the succeeding wash waters become more and more clear. The greasier and dirtier the wool is the more water must be used, and the oftener must it be changed.

The following table gives a general idea of the results which I obtained by washing samples of different sorts of wool:

Breed.	Number of changes of water.	Coloration of the water.	Weight of the sample.	Quantity of water used.
			Grams.	*C. cm.*
Merino	5	Red brown, intense	7.762	611.
Southdown	6	Brownish, cinnamon colored, very intense.	12.704	755.
Holstein	4	Yellowish brown	8.327	280.
American, from Buenos Ayres	3	Yellowish turbid	5.066	380.
Oxfordshiredown	3	Light-red brown	7.808	445.
Common short-tailed, coarse-wooled breeds—				
White, from the Radom Government	2	The first-wash water was faintly turbid, whereas the rest were almost clear.	4.120	300.
Black, from the Canero district of Kijew Government.	2	......do	3.740	250.
Black, from the Schitomir district of Wolyview.	4	......do	4.516	240.
Black, from the Haysini district of Podolien.	1	......do	4.325	325.

The sample having been washed, it is dried on bibulous paper, not in hot air, but at the ordinary temperature. Merino wool must be allowed to dry not less than six days; that of other breeds, not less than four days. The drying lasts so long because it must be conducted at the ordinary temperature, 63° to 70° Fahr. At a higher temperature, the wool dries faster, but it also loses a portion of its hygroscopic moisture, which loss would retard the further analysis. The sample, after drying, is blown and shaken out again, since a few particles of dirt may still have been retained by the fat and excrement in the unwashed wool. Such particles may now very easily be removed.

The dried wool is weighed; the loss in weight is compared to the weight of the unwashed wool. Thus is obtained the weight of the Group A, and from this, the per cent. of the loss is easily calculated.

The fat, B, which is insoluble in water, must now be determined, and it is removed by means of solvents which dissolve fats, as ether or carbon disulphide.

To free the wool perfectly from fat is not a difficult operation; it however requires care and accuracy. Without these, the operator who would determine fat in wool will not obtain exact results. The sample must be soaked in ether or carbon disulphide. Suppose the soaking has continued long enough until all fat is dissolved, if the wool be taken out of the liquid, there is removed with it a certain quantity of the solvent with its accompanying fat. When this evaporates from the sample, it leaves behind its fat in the wool, and although this fat amounts to very little, it will, with a small sample, introduce a perceptible error.

In order to avoid such errors, Martini and Winkler propose a special apparatus. (See "*Das Schaf,*" by May, Breslau, 1868, page 549.) [The description of this apparatus is omitted in this translation.] For several reasons, I consider their apparatus as unsatisfactory, since by its use too much time and attention are required.

In regard to the selection of a solvent, I decidedly prefer carbon disulphide to ether. The removal of the fat requires a preliminary six hours' soaking, and a solvent is desirable which is not very volatile, since by the rapid evaporation of the solvent, the liquid surface in the vessel with the wool sinks, and the wool then becomes exposed. Experiments have convinced me that carbon disulphide possesses this property, that it is much less volatile than ether. This will be evident from the following trials: Some ether was poured into a small flask. The flask with the ether weighed 74.02 grams. The ether was then poured into a shallow dish, which it filled. The diameter of the dish was 80 centimeters. The temperature of the surrounding air in the laboratory was 53° Fahr. The evaporation commenced at 11.40 a. m.; all the ether was gone at 1.32 p. m.; therefore the evaporation lasted one hour and fifty-two minutes. The empty flask weighed 54.67 grams. Hence it follows that 19.35 grams of ether evaporated in one hour and fifty-two minutes. The carbon disulphide with the flask weighed 60.91 grams. It was poured at the same time as the ether into a dish of the same dimensions, and filled it almost to the brim. However, at the end of one hour and fifty-two minutes it had not completely evaporated. The remaining portion was poured back into the flask, and both weighed 51.24 grams. Hence it follows that in one hour and fifty-two minutes, under equal circumstances, only 9.62 grams of carbon disulphide evaporated.

Besides its lesser volatility, carbon disulphide has the advantage that it is much cheaper than ether, which is a desirable feature, since a wool analysis requires a considerable quantity of solvent.

The incompleteness of the Martini-Winkler apparatus for the removal of the fat from wool induced me to construct a particular apparatus for the aforesaid purpose. I call it the "Eurianalysator." [The description of this apparatus is omitted in this translation.]

My eurianalysator works automatically without requiring constant attention, and it perfectly enables one (*a*) to filter carbon disulphide through wool at pleasure for a long time, (*b*) to know the quantity of carbon disulphide used, (*c*) to remove the last trace of grease from the wool, and (*d*) to separate the soiled carbon disulphide from the clean during the progress of the work.

When all the carbon disulphide has evaporated from the wool the latter is weighed, and the difference between this weight and that of the washed and dried wool is noted. This difference is the quantity B, which must be calculated to percentage on the weight of the unwashed sample.

The hygroscopic quality of the wool which has lost the grease which covered the surface of the fibers in the unwashed fleece is slightly different from that which is peculiar to the raw wool. This is the reason why it is better to take a fresh sample of the raw fleece for the determination of the hygroscopic moisture; for this purpose, we have directed in the beginning of our method of analysis that the sample be divided into two halves, of which one shall serve for the determination of the hygroscopic moisture.

This is very easily estimated. A thermometer is placed in a desiccator, a gas burner raises the temperature of the desiccator to 212° Fahr. The sample which has thus far been preserved from dampness and heat is weighed and placed in the desiccator. The weighing is repeated three or four times with intervals of five or ten minutes drying until the weight is constant. The calculated loss in weight expressed in percentage of the weight of the sample determines the hygroscopic moisture.

The following table shows the results of wool analyses which I and my students have obtained. All my own results are designated by asterisks. The pure wool substance in the last column of the table was determined by difference.

The statements of these tables justify us in arriving at the following conclusions in regard to the composition of the fleece:

(*a*) The hygroscopic quality is almost as great in the non-merino wools as in the merino fleece.

(*b*) In the fleece of the non-merino wools, the quantity of pure wool substance is greater than in the merino wools, which are rich in insoluble animal secretions.

(*c*) The least amount of wool substance in the fleece of non-merino breeds is in that of the Southdown sheep, and it is occasioned by the greater content of substances of the Group A.

(*d*) The largest amount of the pure wool fiber is contained in the fleece of the common short-tailed coarse-wooled breeds, and this is because it contains so little of those constituents soluble in water and carbon disulphide.

Breed and character of the sample.	Hygroscopic moisture.	Soluble in water.	Soluble in carbon disulphide.	Pure wool substance.
Merino.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Negretti buck from Konska-Wola	15.42	47.28	21.61	15.69
Do	14.48	40.77	24.53	20.22
Do	14.74	44.23	24.21	16.82
Do	10.15	48.21	19.49	22.15
Do	11.72	54.73	13.33	20.22
Negretti sheep from Konska-Wola	11.81	44.54	26.10	17.55
Do	10.96	51.39	13.39	24.26
Australian merino	13.23	33.57	13.24	39.96
* Rambouillet buck from the Karlow sheep stalls	11.45	46.95	14.83	26.77
Southdown.				
From a buck from Poland	8.18	62.41	4.61	24.30
Do	10.63	51.53	8.83	29.01
Do	10.62	58.03	6.39	24.96
Do	13.12	57.64	4.06	25.18
* *From a buck from England*	11.90	39.21	9.73	39.16

Breed and character of the sample.	Hygroscopic moisture.	Soluble in water.	Soluble in carbon disulphide.	Pure wool substance.
Oxfordshiredown.				
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
From a buck from Poland	10.86	41.27	4.83	43.04
*Do	12.90	37.59	5.02	44.49
Do	11.46	45.37	5.49	37.78
Holstein.				
From a buck from Poland	8.04	51.02	8.25	32.69
Do	10.81	47.48	1.04	40.67
Do	17.15	48.37	1.90	32.58
Do	15.83	25.14	0.95	58.08
*Do	13.58	43.66	2.16	40.60
*American from Buenos Ayres	11.87	16.10	4.91	67.12
Common short-tailed.				
*Black from a buck from the Haysini district of Podolien	12.23	5.66	1.82	80.29
*Black from a buck from the Kijew Government	11.59	3.61	0.88	83.92
*Black from a buck from the Schitomir district of the Wolyn Government	10.60	6.35	2.45	80.60
*White from the Radom Government	10.74	7.40	0.65	81.21

V.—*CONCLUSION AS TO CLASSIFICATION.*

From the preceding facts, we see that wool comes into the trade in a very great variety of purity, some with not over 10 or 15 per cent. of actual wool fiber, others with 80 or 85 per cent., and that some of the contaminations are soluble in cold water, others requiring hot water and soap or other chemicals, and still others, mechanical, and requiring special machinery for their removal.

From all this it will be seen that any classification of wools for tariff, founded on any of the physical characters named, or on the alleged treatment, as "unwashed," "washed," or "scoured," must of necessity be entirely arbitrary, and in very many cases uncertain and unsatisfactory, since each character is variable in itself, and by its combinations allows of an infinite number of gradings and sorts, so that, however classified, according to these characters there will be many samples which will lie so near the assumed border lines that their actual place will be a matter of opinion rather than of demonstration.

A classification may, however, be founded on chemical characters determined by the amount of actual wool fiber, which may be used as the fixed quantity for rating a specific tariff. The actual wool fiber may be readily and accurately determined, by chemical methods, beyond any reasonable question.

Inasmuch as the commercial values depend greatly on the fineness of the wools, and any tariff classification founded on the weight of actual wool substance would bear most heavily on the coarser and cheaper sorts, the ad valorem element may be combined with the fixed element suggested, in order to meet any special ends other than that of mere revenue.

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OF THE

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FOR

THE YEAR 1887.

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LETTER OF TRANSMITTAL.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., January 10, 1888.

SIR: In conformity with the requirements of the act of incorporation approved March 3, 1863, I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year.

O. C. MARSH,
President of the National Academy of Sciences.

The PRESIDENT OF THE SENATE.

REPORT

OF

THE NATIONAL ACADEMY OF SCIENCES.

The National Academy of Sciences was established by act of Congress in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

The object of the Academy is to advance science, and especially to investigate, examine, experiment, and report on any subject of science or art, whenever called upon by any Department of the Government.

The Academy contains at present about one hundred members, and these have all been selected for their original researches in science. They represent within their ranks nearly every department of knowledge, and their services, in accordance with the charter of the Academy, are always at the disposal of the Government, without compensation.

SESSIONS OF THE NATIONAL ACADEMY.

During the past year, the Academy has held three sessions. The first was the regular annual meeting held in Washington, D. C., April 19 to 22, 1887; the second was a scientific session, in New York City, November 8 to 11, 1887; and the third was a special session, in New York, November 9, 1887.

STATED SESSION.

HELD IN WASHINGTON CITY, APRIL 19 TO 22, 1887.

The Washington session was held in the National Museum, the president, Prof. O. C. Marsh, presiding.

The following members were present during the session:

Abbe.
Abbot.
Baird.
Barker.
Bell.
Billings.
Brush.
Cope.
Dana, E. S.
Dutton.
Farlow.
Gibbs, J. W.
Gill.
Gould.
Hague.
Hall, A.
Hill, G. W.
Hunt.
Langley.
Marsh.
Meigs.
Mitchell.
Morse.
Newcomb.
Powell.
Putnam.
Remsen.
Schott.
Walker.
Wright.
Young.

At this session, the following papers were read:

1. **Hunt, T. Sterry**: On Chemical Integration.
2. **Loomis, Elias**: On the Rainless Character of the Sahara. (Read by Mr. Young.)
3. **Cope, E. D.**: On the Fore Limb and Shoulder Girdle of Eryops, and on the Vertebrates of the Triassic.
4. **Dutton, C. E., and Hayden, Everett**: Results of the Investigation of the Charleston Earthquake.
5. **Langley, S. P.**: A New Map of the Spectrum.
6. **Farlow, W. G.**: The Vegetation of the Hot Springs of the Yellowstone Park. Discussed by Mr. Cope.
7. **Langley, S. P.**: The Color of the Sun.
8. **Remsen, Ira**: Chemical Constitution and Taste.
9. **Remsen, Ira**: On a New Class of Compounds analogous to the Phthaleins.
10. **Greely, A. W.** (by invitation of the Academy): On the Barometric Oscillation—Diurnal and Annual.
11. **Williams, G. H.** (by invitation of the Academy): On the Serpentine of Syracuse, New York.
12. **Gibbs, J. W.**: On the Determination of Orbits of Planets and Comets. Discussed by Messrs. A. Hall, G. W. Hill, and Newcomb.
13. **Bell, A. G.**: On the Ancestry of the Deaf.
14. **Bell, A. G.**: On the Notation of Kinship. Discussed by Mr. Abbe.
15. **Dall, W. H.** (by invitation of the Academy): On Floridian Geology. Discussed by Mr. Gilbert.
16. **Walcott, C. D.** (by invitation of the Academy): On the Taconic System of Emmons. Discussed by Mr. Hunt.
17. **Irving, R. D.** (by invitation of the Academy): Is there a Huronian Group?
18. **Le Conte, Joseph**: On some Phenomena of Binocular Vision.
19. **Wright, A. W.**: The Effect of Magnetization on the Electrical Resistance of Metals. Discussed by Messrs. Young and Bell.
20. **Wilder, B. G.** (by invitation of the Academy): On the Brain of Ceratodus, with Remarks on the General Morphology of the Vertebrate Brain. Discussed by Messrs. Cope and Gill.
21. **Remsen, Ira**: On the Decomposition of Diazo Compounds by Alcohol. (Read by title.)
22. **Gill, T.**: Outline of the Ichthyological System. (Read by title.)

ELECTIONS.

Mr. John S. Billings was elected treasurer, in place of Mr. Coffin, whose term of office expired with this session.

The following members were selected for the council for the ensuing year: Messrs. S. F. Baird, G. J. Brush, S. P. Langley, M. C. Meigs, E. C. Pickering, and Ira Remsen.

RECOMMENDATIONS FROM THE COUNCIL.

The following recommendations from the council were adopted by the Academy:

1. That the assessment for the ensuing year be $5.

2. That the vote accepting the resignation of Mr. Agassiz be reconsidered.

3. That, in accordance with Mr. Agassiz's request, his name be transferred to the list of honorary members.

4. That Dr. John S. Billings be, and he hereby is, authorized to receipt for, or to indorse, checks on interest due.

5. That the Academy appoint a committee of three members, resident in Washington, to audit the accounts and securities of the Academy on their transfer to the new treasurer. The president appointed Messrs. Langley, Newcomb, and A. Hall as such committee.

HOME SECRETARY'S REPORT.

The home secretary submitted the following report:

APRIL 20, 1887.

In addition to the routine work of the year, the second volume of the biographical notices was printed last summer, and distributed to members. An edition of five hundred copies was printed. An edition of two hundred and fifty copies of the first volume of the biographical notices was printed in 1877, and this edition is now exhausted.

The printing of Part II of the third volume of the memoirs was finished December last, but very many of the plates belonging to the edition were burnt, and the distribution of the volume has been delayed.

REPORTS OF COMMITTEES.

The president, on behalf of the committee on ways and means to provide a fund for the Academy, stated that Dr. S. Weir Mitchell had taken special charge of some features of this business, and it is hoped will meet with success.

Mr. A. Hall, for the committee on the election of foreign associates, reported that two nominations had been made.

The committee on the astronomical day, eclipse of 1886, and new observatory, the committee on the tariff classification of wool, and the committee on opium, were discharged.

The president stated that Mr. Hilgard had resigned his position on the board of trustees of the Watson fund, and that Mr. Gould had been appointed to fill the vacancy.

Mr. Barker, chairman of the committee on the Henry Draper medal, reported that the committee recommends that the second Henry Draper medal be awarded to Prof. Edward C. Pickering, director of the Harvard Observatory, for his recent work in astronomical photometry and photography. This recommendation was adopted.

THE JAMES WATSON MEDAL.

At a public session of the Academy, held on the evening of April 20, the first James Watson medal and the sum of $100 in gold were presented to Dr. B. A. Gould, for his valuable labors for nearly forty years in promoting the progress of astronomical science.

At the same session, the following biographical memoirs were read:

Of President W. B. Rogers, by President F. A. Walker.

Of Dr. E. Tuckerman, by Prof. W. G. Farlow.

CONSTITUTIONAL AMENDMENT.

The Academy, in committee of the whole, adopted the following amendment to the constitution, which will be voted on at the next stated session:

That Article VI, section 1, be changed to read as follows: "All investments shall be made by the treasurer, in the corporate name of the Academy, in stocks of the United States; or, with the approval of the council, in State bonds, or first-mortgage bonds on real estate."

The treasurer shall have authority, with the approval of the council, to sell and transfer any United States bonds held by him in the corporate name of the Academy.

The pending amendment to Article V, section 6, was not adopted.

NEW MEMBERS.

The following new members were elected: Prof. Henry P. Bowditch, Prof. George H. Cook, and Prof. Thomas C. Mendenhall.

FOREIGN ASSOCIATES.

Prof. A. W. Hofmann, of Berlin, and J. P. Joule, esq., of Manchester, England, were elected foreign associates of the Academy.

TREASURER'S REPORT.

WASHINGTON, *D. C.*, *May* 21, 1887.

The committee of the Academy appointed to examine its accounts and securities have this day found them as described in the accompanying summary, and in a detailed account in the hands of Dr. J. S. Billings, which account they have separately signed after witnessing the transfer.

S. P. LANGLEY,
S. NEWCOMB,
ASAPH HALL,
Committee.

NATIONAL ACADEMY OF SCIENCES, *May* 21, 1887.

Transfer of bonds and securities of the National Academy of Sciences by J. H. C. Coffin to Dr. J. S. Billings, his successor as treasurer.

1. *Cash-fund balances to the credit of the following accounts, April* 19, 1887.

General fund	$167.46
Bache fund	2,350.73
Watson fund	1,415.05
Draper fund	568.54
Smith fund	818.00
Total	5,319.78

Transferred as per receipt of April 26, 1887.

2. *The Academy seal.*

Order to Bank of Washington to deliver to Dr. Billings or order.

3. *Securities held in trust.*

The committee, Messrs. Brush, Remsen, and Young, appointed to examine the following securities, found they were correct:

a. General fund.

District of Columbia 3.65 bonds		$500

b. Bache fund.

United States 4½ per cent. bonds, registered	$42,100	
United States 4 per cent. bonds, registered	3,850	
Davenport 6 per cent. bonds, coupon	1,000	
Philadelphia 6 per cent. bonds, registered	600	
		47,550

Deed for 160 acres of Missouri lands to A. D. Bache, not transferred to the Academy.

c. Invested income of the Bache fund.

District of Columbia 3.65 bonds		1,500

d. Joseph Henry fund.

An agreement with the Pennsylvania Company for insurance on lives and granting annuities, as to the final disposition of the Joseph Henry fund of $40,000.

The above will not be available until the decease of all Professor Henry's children.

e. Watson fund.

United States 4½ per cent. bonds, registered	$6,200	
United States 4 per cent. bonds, registered	850	
Certificates for 134 shares of the capital stock of the Michigan Life Insurance Company	6,700	
		13,750

f. Henry Draper medal fund.

United States 4 per cent. bonds, registered		5,000

Deed of trust of Mary Anna Palmer Draper to the National Academy of Sciences.

g. J. Lawrence Smith medal fund.

United States 4½ per cent. bonds, registered		7,200

Deed of trust of Sarah Julia Smith to the National Academy of Sciences.

Amount of available securities		75,500

DEATH OF MEMBERS.

The President announced the death, on March 8, 1887, of Mr. James B. Eads, of Saint Louis, Mo.

Mr. William Sellers was appointed to prepare a biographical notice.

The following members were also appointed to prepare biographical memoirs:

Of Prof. James C. Watson, Prof. E. S. Holden.

Of General J. G. Barnard, President F. A. P. Barnard.

INVITATIONS.

It was announced that members of the Academy were invited to make use of the rooms of the Cosmos Club during their stay in Washington.

Mr. A. G. Bell invited the members of the Academy to a reception at his house on the evening of April 21.

The Academy adjourned April 22, to meet in scientific session in New York City, November 8, 1887.

SCIENTIFIC SESSION.

HELD IN NEW YORK CITY, NOVEMBER 8 TO 11, 1887.

A scientific session, for the reading of papers only, having been called by the council, as announced at the April session, the Academy met at Columbia College, New York City, on November 8, 1887.

Dr. Wolcott Gibbs presided on November 8, and the president, Prof. O. C. Marsh, on the succeeding days.

The following members were present during the session:

Abbe.
Abbot.
Barker.
Barnard.
Billings.
Brooks.
Brush.
Chandler.
Cook, G. H.
Cope.
Coues.
Dana, E. S.
Dana, J. D.
Gibbs, W.
Gill.
Hall, A.
Hall, J.
Hunt.
Johnson.
Marsh.
Mayer.
Mendenhall.
Morton.
Newberry.
Packard.
Peters.
Pickering.
Pumpelly.
Rogers, W. A.
Rood.
Scudder.
Trowbridge, W. P.
Wright.
Young.

The following papers were read and discussed:

1. MENDENHALL, T. C.: Seismoscopes and Seismological Investigations.
2. COPE, E. D.: On the Primary Specializations of the True Fishes.
3. ROGERS, W. A.: A Study of the Behavior of Metals under Variations of Temperature.
4. HUNT, T. STERRY: Chemism in its Relations to Temperature and Pressure.
5. COPE, E. D.: On the Mechanical Origin of the Structures of the Hard Parts of the Mammalia.
6. HUNT, T. STERRY: Progressive Series in Chemistry.
7. DANA, J. D.: Kilauea, a Basalt Volcano.
8. MITCHELL, HENRY: Circulation of the Sea through New York Harbor. (Read by Mr. Barnard.)
9. ROOD, OGDEN N.: On a Study of Color Contrast.
10. BROOKS, W. K.: On a Relative Variability of Men and Women.
11. BROOKS, W. K.: On a New Form of Reproduction in Medusæ.
12. BROOKS, W. K.: On the Lucayan Indians. (Read by title.)
13. MAYER, A. M.: Experiments in Measurements of Statical Electricity in Absolute Units.
14. MAYER, A. M.: On Potential as measured by Work; a Mathematical Discussion.
15. GILL, T.: A Comparison of Antipodal Faunas.

16. TROWBRIDGE, W. P.: On a Discovery recently made in Connection with the Flight of Birds.
17. PICKERING, E. C.: On the Determination of Star Magnitudes by Photography.
18. HALL, A.: On the Constant of Aberration.
19. NEWBERRY, J. S.: The Cretaceous Coals of Western North America.
20. NEWBERRY, J. S.: The Future of Gold and Silver Production.
21. LANGLEY, S. P.: The Temperature of the Moon. (Read by the Home Secretary.)
22. MICHELSON, A. A., and MORLEY, E. W. (by invitation of the Academy): On a Method of making the Wave Length of Sodium Light the Absolute Standard of Length.

The scientific session closed November 11, 1887.

SPECIAL SESSION.

HELD IN NEW YORK CITY, NOVEMBER 9, 1887.

A special session of the Academy having been called by the council, in accordance with Article III, section 1, of the constitution, the Academy convened at Columbia College, November 9, 1887; the president, Prof. O. C. Marsh, presiding.

The president stated the object of the meeting, which was to consider his annual report to Congress. He gave an outline of the report, and requested that it might include the proceedings of the present meeting, and the reports made for the Treasury Department.

The president also stated that two requests from the Treasury Department had been received since the last meeting, and that he had appointed the following committees to make the necessary investigations:

On opium.—Prof. Ira Remsen, *chairman*, Prof. G. F. Barker, and Prof. C. F. Chandler.

On sugar determinations.—Prof. A. W. Wright, *chairman*, Prof. E. S. Dana, and Prof. C. S. Hastings of Yale College.

RECOMMENDATIONS FROM THE COUNCIL.

The following recommendations from the council were adopted:

1. That the medal of Professor Oppolzer be deposited in the National Museum at Washington, with the Bache medals, subject to the order of the Academy.

2. That the president be authorized to include in his annual report to Congress, the proceedings of the present meeting, the report on opium, and the report on sugar determinations.

NOMINATIONS.

Four nominations for membership in the Academy were read by the home secretary.

The home secretary then presented the report of the committee appointed to examine the securities and accounts of the Academy, and to witness the transfer of funds from the outgoing to the new treasurer.

The home secretary also read the following new rule, which, on motion, was referred to the council:

RULE XXIV. Lists of the more important original works of nominees for membership, provided they have been filed with the home secretary at least sixty days before the time appointed for the election of new members, shall be printed, and distributed to members for their information.

RESOLUTION.

The following resolution was adopted:

Resolved, That the thanks of the Academy be tendered to the president and trustees of Columbia College, for their courtesy in granting the use of commodious rooms for the meetings of the Academy.

DEATH OF MEMBERS.

The president announced the death of Prof. S. F. Baird, who died August 19, 1887.

Mr. J. S. Billings was appointed to prepare a biographical memoir.

DEATH OF FOREIGN ASSOCIATE.

The president announced the death of Prof. G. R. Kirchoff, foreign associate of the Academy, who died October 17, 1887, in Berlin.

The president announced that in December last an invitation was received from the Académie des Sciences of Paris, requesting him to appoint a delegate from the National Academy of Sciences to an international conference of astronomers, to consider a general plan for photographing the heavens, to be held at Paris, beginning April 16, 1887. In accordance with this request, Prof. C. H. F. Peters, director of the Litchfield Observatory of Hamilton College, Clinton, N. Y., was appointed delegate of the Academy.

The president stated that Professor Peters attended this conference and had since been requested to prepare a report of the meetings, to be included in the proceedings of the Academy for the year 1887. (See Appendix F, p. 47.)

The special session was then adjourned.

On the evening of November 9, Professor Pickering gave a lecture on the researches he had recently conducted in continuation of Dr. Draper's works of photographing the stars.

Respectfully submitted.

O. C. MARSH,
President of the National Academy of Sciences.

APPENDICES.

13

APPENDIX A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, Saint Louis, Mo.; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States Navy, District of Columbia; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania; J. L. LeConte, United States Army, Pennsylvania; J. Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, junior, Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California; their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SEC. 2. *And be it further enacted,* That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise;

to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institution, and to report the same to Congress.

SEC. 3. *And be it further enacted,* That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the Academy shall, whenever called upon by any Department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

Approved, March 3, 1863.

AN ACT to amend the act to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act to incorporate the National Academy of Sciences, approved March three, eighteen hundred and sixty-three, be, and the same is hereby, so amended as to remove the limitation of the number of ordinary members of said Academy as provided in said act.

Approved, July 14, 1870.

DEPARTMENT OF STATE, *June* 10, 1882.

True copies.

SEVELLON A. BROWN,
Chief Clerk.

AN ACT to authorize the National Academy of Sciences to receive and hold trust funds for the promotion of science, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the National Academy of Sciences, incorporated by the act of Congress approved March third, eighteen hundred and sixty-three, and its several supplements, be, and the same is hereby, authorized and empowered to receive bequests and donations, and hold the same in trust, to be applied by the said Academy in aid of scientific investigations, and according to the will of the donors.

Approved, June 20, 1884.

DEPARTMENT OF STATE, *June* 24, 1884.

A true copy.

SEVELLON A. BROWN,
Chief Clerk.

APPENDIX B.

CONSTITUTION AND RULES OF THE NATIONAL ACADEMY OF SCIENCES.

As amended and adopted April 17, 1872, and further amended April 20, 1875, April 21, 1881, April 19, 1882, and April 18, 1883.

PREAMBLE.

Empowered by the act of incorporation enacted by Congress, and approved by the President of the United States, on the 3d day of March, A. D. 1863, and in conformity with the amendment to said act, approved July 14, 1870, the National Academy of Sciences adopts the following amended constitution and rules:

ARTICLE I.—OF MEMBERS.

SEC. 1. The Academy shall consist of members, honorary members, and foreign associates. Members must be citizens of the United States.

SEC. 2. Members who, from age or inability to attend the sessions of the Academy, wish to resign the duties of active membership, may, at their own request, be transferred to the roll of honorary members by a vote of the Academy.

SEC. 3. The Academy may elect fifty foreign associates.

SEC. 4. Honorary members and foreign associates shall have the privilege of attending the meetings, and of reading and communicating papers to the Academy, but shall take no part in its business, shall not be subject to its assessments, and shall be entitled to a copy of the publications of the Academy.

ARTICLE II.—OF THE OFFICERS.

SEC. 1. The officers of the Academy shall be a president, a vice-president, a foreign secretary, a home secretary, and a treasurer, all of whom shall be elected for a term of six years, by a majority of votes present, at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner at the session when such vacancy occurs, or at the next stated session thereafter, as the Academy may direct. A vacancy in the office of treasurer or home secretary may, however, be filled by appointment of the president of the Academy until the next stated session of the Academy.

SEC. 2. The officers of the Academy, together with six members to be elected by the Academy at the first stated session in each year, shall constitute a council for the transaction of such business as may be assigned to them by the constitution or the Academy.

SEC. 3. The president of the Academy, or, in case of his absence or inability to act, the vice-president, shall preside at the meetings of the Academy and of the council; shall name all committees except such as are otherwise especially provided for; shall refer investigations required by the Government of the United States to members especially conversant with the subjects, and report thereon to the Academy at its session next ensuing; and, with the council, shall direct the general business of the Academy.

It shall be competent for the president, in special cases, to call in the aid, upon committees, of experts or men of special attainments, not members of the Academy.

SEC. 4. The foreign and home secretaries shall conduct the correspondence proper to their respective departments, advising with the president and council in cases of doubt, and reporting their action to the Academy at one of the stated sessions in each year.

It shall be the duty of the home secretary to give notice to the members of the place and time of all meetings, of all nominations for membership, and of all proposed amendments to the constitution.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the home secretary.

SEC. 5. The treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the council may require. He shall collect all dues from members, and keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the April session. He shall be the custodian of the corporate seal of the Academy.

ARTICLE III.—OF THE MEETINGS.

SEC. 1. The Academy shall hold one stated session in each year, in the city of Washington, on the third Tuesday in April, and another may be held at such place and time as the council shall determine.

Special sessions of the Academy may be called, by order of eight members of the council, at such place and time as may be designated in the call.

Scientific sessions of the Academy may be held at times and places to be designated by a majority of the council.

SEC. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SEC. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business, closed.

SEC. 4. The stated meetings of the council shall be held during the stated or special sessions of the Academy. Special meetings may be convened at the call of the president and two members of the council, or of four members of the council.

SEC. 5. No member who has not paid his dues shall take part in the business of the Academy.

ARTICLE IV.—OF ELECTIONS AND RESIGNATIONS.

SEC. 1. All elections shall be by ballot, and each election shall be held separately, unless otherwise ordered by this constitution.

SEC. 2. The time for holding an election for officers shall be fixed by the Academy at least one day before the election is held.

SEC. 3. The six additional members of the council shall be elected on any day after the first of the first stated session in each year, by each voter inscribing six names on his ballot, and those six who have received more votes than any others shall be declared elected. If two or more names have received the lowest number of votes that would elect, additional balloting shall be had for as many members as remain each time to be elected until the number is full.

The term of the members so elected shall commence at the close of the session at which they are elected, and continue until the close of the first stated session in the next year.

SEC. 4. Nominations of members may be made in writing, signed by any five members of the Academy, at any stated session, to be voted on at the next stated session held in Washington, and each nomination shall, at the time of election, be accompanied by a written list of the original works of the nominee.

SEC. 5. Elections for membership shall be held in the following manner: Each member may inscribe on a ballot not more than five names of nominees selected from the list. Absent members may send such ballots to the home secretary. From the seven names receiving the highest number of votes in this preference ballot, the members present may proceed to elect new members in the following manner: At each ballot, each member present may vote for not exceeding three persons, and the person receiving the highest number of votes shall be declared elected, provided that he received two-thirds of the votes cast and that his name appear on not less than twenty ballots; and provided further, that the number of members of the Academy be not already one hundred or over, in which case to be declared to be elected he must receive four-fifths of the votes cast, and his name must appear on at least twenty-five ballots.

Should several candidates have the same minimum number of votes on the preference list, the requisite number for completing the list shall be selected from them by a two-thirds vote of the members present.

Election of members shall be held only at the regular stated session of each year held in Washington, and not more than five members shall be elected at that session.

Before and during elections, a discussion of the merits of nominees will be in order.

The election of members may be suspended at any time by a majority vote of the members present.

SEC. 6. Every member elect shall accept his membership, personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SEC. 7. Foreign associates may be nominated by a committee of five members to be appointed for that purpose by the president, and elected at any stated session by a two-thirds vote of the members present. The election shall be had by each member indicating on a ballot those names for which he votes, and those nominees whose names appear on two-thirds of the ballots shall be declared elected.

SEC. 8. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate secretary to each member on his acceptance of his membership, and to foreign associates on their election.

SEC. 9. Resignations shall be addressed to the president and acted on by the Academy.

ARTICLE V.—OF SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

SEC. 1. Communications on scientific subjects shall be read at scientific meetings of the Academy, and papers by any member may be read by the author, or by any other member, notice of the same having been previously given to the secretary.

SEC. 2. Any member of the Academy may read a paper from a person who is not a member, and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

Persons who are not members may read papers on invitation of the president, with the advice of the council.

SEC. 3. The Academy may provide for the publication, under the direction of the council, of proceedings, memoirs, and reports.

SEC. 4. Propositions for investigations or reports by the Academy shall be submitted to the council for approval, except those requested by the Government of the United States, which shall be acted on by the president, who will in such cases report their results to the Government as soon as obtained, and to the Academy at its next following stated session.

SEC. 5. The advice of the Academy shall be, at all times, at the disposition of the Government, upon any matter of science or art within its scope.

Sec. 6. An annual report to be presented to Congress shall be prepared by the president, and before its presentation, submitted by him, first to the council, and afterwards to the Academy, at one of the stated sessions.

Sec. 7. Medals and prizes may be established, and the means of bestowing them accepted by the Academy, upon the recommendation of the council, by whom all the necessary arrangements for their establishment and award shall be made.

Bequests and trusts having for their object the advancement of science may also be accepted and administered by the Academy.

Article VI.—OF THE PROPERTY OF THE ACADEMY.

Sec. 1. All investments shall be made by the treasurer, in the corporate name of the Academy, in stocks of the United States.

Sec. 2. No contract shall be binding upon the Academy which has not been first approved by the council.

Sec. 3. The assessments required for the support of the Academy shall be fixed by the Academy on the recommendation of the council.

Article VII.—OF ADDITIONS AND AMENDMENTS.

Additions and amendments to the constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change must be given at a stated session, and shall be referred to the council, which may amend the proposition, and shall report thereon to the Academy at the same session. Its report shall be considered by the Academy in committee of the whole for amendment.

The proposition as amended, if adopted in committee of the whole, shall be voted on at the next stated session, and if it receives two-thirds of the votes cast, it shall be declared adopted.

Absent members may send their votes on pending changes in the constitution to the home secretary in writing, and such votes shall be counted as if the member were present.

RULES.

I. In the absence of any officer, a member shall be chosen to perform his duties temporarily, by a plurality of *viva voce* votes, upon open nominations.

II. The accounts of the treasurer shall be referred to an auditing committee of three members, to be appointed by the president at the meeting at which the accounts are presented, which committee shall report before the close of that session, and shall then be discharged.

The bonds, securities, and other property owned or held in trust by the Academy shall be inspected and verified by a committee to be annually appointed by the president. The report of this committee shall be presented to the Academy at its first stated session in each year, and referred with the accounts to the auditing committee.

III. A committee of arrangements consisting of five members shall be appointed by the president for each stated session of the Academy. This committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, etc.; and to arrange the order of reading, and, in general, to attend to all business and scientific arrangements.

IV. At the meetings, the order of business shall be as follows:

1. Chair taken by the president, or, in his absence, by the vice-president.
2. Roll of members called by home secretary.
3. Minutes of the preceding meeting read and approved.
4. Stated business.
5. Reports of president, secretaries, treasurer, and committees.
6. Business from council.
7. Other business.
8. On the last days of the session, the rough minutes of that day's proceedings are to be read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless suspended by unanimous consent.

VI. Unless otherwise ordered by the Academy, the scientific meetings shall be convened at noon.

VII. The death of members shall be announced by the president on the last day of any session, when a member shall be selected by the president to furnish a biograpical notice of the deceased at the next stated session. If such notice be not then furnished, another member may be selected by the president in place of the first, and so on until the duty is performed.

VIII. All discussions as to the claims and qualifications of nominees at meetings of the Academy will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the Academy at the time of the discussion.

IX. The secretaries will receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy.

X. Memoirs shall date in the records of the Academy from the date of their presentation to the Academy, and the order of their presentation shall be that in which they were registered, unless changed by consent of the author.

XI. Papers from persons not members, read before the Academy, and intended for publication, shall be referred, at the meeting at which they are read, to a committee of members competent to judge whether the paper is worthy of publication. Such committee shall report to the

Academy as early as practicable, and not later than the next stated session.

XII. An annual of the Academy shall be prepared and published by the secretaries.

XIII. The printing of the Academy shall be under the charge of a committee of publication, to consist of the home secretary, and four other members to be named by the president, with the advice and consent of the council.

XIV. The annual report of the Academy may be accompanied by a memorial to Congress in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XV. The proper secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XVI. The books, apparatus, archives, and other collections of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles so deposited shall be kept by the home secretary, who is authorized to employ a clerk to take charge of them.

XVII. A stamp corresponding to the corporate seal of the Academy shall be kept by the secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels, or other proper marks of similar device, shall be placed upon objects not admitting of the stamp.

XVIII. On the first day of each stated session, immediately after calling the roll of members, a recording secretary shall be elected by a plurality of members present, to assist the home secretary in keeping the records of the session.

XIX. It shall be the duty of the committee of arrangements to fix the length of time to be devoted to reading of all papers submitted, and to limit the time to be occupied in their discussion.

XX. Ballots for election of members may be sent by sealing them up in a blank envelope, and inclosing this in another, across the back of which is written the name of the sender, and which is addressed to the home secretary; such envelopes will be opened only by the tellers.

XXI. Any rule of the Academy may be amended, suspended, or repealed on the written motion of any two members, signed by them, and presented at a stated session of the Academy, provided the same shall be approved by a majority of the members present.

XXII. Nominations for membership should state the full name, residence, the official position, and the special scientific studies of the candidate. A form of nomination shall be prepared by the home secretary.

By a resolution adopted January 12, 1864, the president is, *ex officio*, a member of all Government committees of the Academy.

APPENDIX C.

ORGANIZATION OF THE ACADEMY, 1887.

	Expiration of term.
MARSH, O. C., *President*	April, 1889.
NEWCOMB, S., *Vice-President*	April, 1889.
GIBBS, WOLCOTT, *Foreign Secretary*	April, 1892.
HALL, A., *Home Secretary*	April, 1889.
BILLINGS, JOHN S., *Treasurer*	April, 1893.

ADDITIONAL MEMBERS OF COUNCIL, 1887-'88.

BAIRD, S. F.
BRUSH, G. J.
LANGLEY, S. P.
MEIGS, M. C.
PICKERING, E. C.
REMSEN, IRA.

COMMITTEES OF THE ACADEMY.

On Ways and Means to Provide a Fund for the Academy.

ROGERS, FAIRMAN, *Chairman.*
CHANDLER, C. F.
MARSH, O. C.
MITCHELL, S. WEIR.
PUMPELLY, R.

On Weights, Measures, and Coinage.

BARNARD, F. A. P., *Chairman.*
GIBBS, WOLCOTT.
HILGARD, J. E.
MEIGS, M. C.
NEWCOMB, S.
NEWTON, H. A.
PEIRCE, C. S.
TROWBRIDGE, W. P.

On the Election of Foreign Associates.

GIBBS, WOLCOTT, *Chairman.*
DANA, J. D.
GOULD, B. A.
HALL, A.
NEWCOMB, S.

On Reserving Public Lands on and near Mount Whitney, California, for Scientific Purposes.

LANGLEY, S. P., *Chairman.*
BREWER, W. H.
POWELL, J. W.

On Publication.

THE HOME SECRETARY.
BAIRD, S. F.
COFFIN, J. H. C.
NEWCOMB, S.
POWELL, J. W.

On Publications of the Academy.

Gill, T.

On the Relation of the Academy to the Government.

The President.
Vice-President.
Secretaries.
Baird, S. F.
Coffin, J. H. C.
Hilgard, J. E.
Meigs, M. C.
Powell, J. W.

GOVERNMENT COMMITTEES.

On Opium, 1887.

Remsen, Ira, *Chairman.*
Barker, G. F.
Chandler, C. F.

On Sugar Determinations.

Wright, A. W., *Chairman.*
Dana, E. S.
Hastings, C. S.

TRUST FUNDS.

Board of Direction of the Bache Fund.

Dana, J. D., *Chairman.*
Hilgard, J. E.
Gibbs, W.

Board of Trustees of the Watson Fund.

Newcomb, S., *Chairman.*
Coffin, J. H. C.
Gould, B. A.

On the Henry Draper Medal.

Barker, G. F., *Chairman.*
Gibbs, W.
Newcomb, S.
Wright, A. W.
Young, C. A.

On the J. Lawrence Smith Medal.

Gibbs, Wolcott, *Chairman.*
Brush, G. J.
Hall, A.
Pumpelly, R.
Rutherfurd, L. M.

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, 1888.*

		Date of election.
Abbe, Cleveland	*Washington, D. C.*	1879
Abbot, Henry L., U. S. A.	*Army Building, New York.*	1872
Allen, J. Asaph	*American Museum, New York City.*	1876
Barker, George F.	3909 *Locust St., Philadelphia, Pa.*	1879
Barnard, Frederick A. P.	*New York City.*	—
Bartlett, William H. C.	75 *Locust Hill Ave., Yonkers, N. Y.*	—
Bell, A. Graham	*Washington, D. C.*	1883
Billings, John S., U. S. A.	*Washington, D. C.*	1883
Bowditch, Henry P	*Cambridge, Mass.*	1887
Brewer, William H.	*New Haven, Conn.*	1880
Brooks, W. K.	*Johns Hopkins University, Baltimore, Md.*	1884
Brown-Sequard, Charles E.	*Paris, France.*	1868
Brush, George J.	*New Haven, Conn.*	1868
Chandler, Charles F	*New York City.*	1874
Chandler, Seth C	16 *Craigie St., Cambridge, Mass.*	1888
Coffin, John H. C., U. S. N.	*Washington, D. C.*	—
Comstock, Cyrus B., U. S. A	*Whitestone, Long Island, N. Y.*	1884
Cook, George H.	*New Brunswick, N. J.*	1887
Cooke, Josiah P.	*Cambridge, Mass.*	1872
Cope, Edward D.	2100 *Pine St., Philadelphia, Pa.*	1872
Coues, Elliott	*Washington, D. C.*	1877
Crafts, James M.	*École des Mines, Paris, France.*	1872
Dalton, J. C.	43 *W. Forty-eighth St., New York City.*	1864
Dana, Edward S.	*New Haven, Conn.*	1884
Dana, James D.	*New Haven, Conn.*	—
Davidson, George	*San Francisco, Cal.*	1884
Dutton, Clarence E., U. S. A.	*Washington, D. C.*	1884
Farlow, W. G	*Cambridge, Mass.*	1879
Ferrel, William	1641 *Broadway, Kansas City, Mo.*	1868
Genth, Frederick A.	*West Philadelphia, Pa.*	1872
Gibbs, Josiah Willard	*New Haven, Conn.*	1879
Gibbs, Wolcott	*Newport, R. I.*	—
Gilbert, Grove K.	*Washington, D. C.*	1883
Gill, Theodore N.	*Washington, D. C.*	1873
Goode, G. Brown	*Washington, D. C.*	1888
Gould, Benjamin A	*Cambridge, Mass.*	—
Hague, Arnold	*U. S. Geological Survey, Washington, D. C.*	1885
Hall, Asaph, U. S. N.	*Washington, D. C.*	1875
Hall, James	*Albany, N. Y.*	—
Hilgard, Eugene W.	*Oakland, Cal.*	1872
Hilgard, Julius E.	*Washington, D. C.*	—
Hill, George W	*Washington, D. C.*	1874
Hill, Henry B.	*Cambridge, Mass.*	1883
Holden, Edward S	*Berkeley, Cal.*	1885
Hunt, T. Sterry	*Montreal, Canada.*	1873
Hyatt, Alpheus	*Soc. of Nat. History, Boston, Mass.*	1875
Jackson, Charles L.	*Cambridge, Mass.*	1883
Johnson, Samuel W.	*New Haven, Conn.*	1866

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* A delay in printing the present report has made it possible to revise the list of members to October 24, 1888.

		Date of election.
King, Clarence	62 *Cedar St., New York.*	1876
Langley, Samuel P	*Washington, D. C.*	1876
Leidy, Joseph	*Philadelphia, Pa.*	1884
Lesley, J. Peter	1008 *Clinton St., Philadelphia, Pa.*	——
Le Conte, John	*Berkeley, Cal.*	1878
Le Conte, Joseph	*Berkeley, Cal.*	1875
Lesquereux, Leo	302 *Fourth St., Columbus, Ohio.*	1864
Loomis, Elias	*New Haven, Conn.*	1873
Lovering, Joseph	*Cambridge, Mass.*	1873
Marsh, O. C	*New Haven, Conn.*	1874
Mayer, Alfred M	*Hoboken, N. J.*	1872
Meigs, Montgomery C., U. S. A	*Washington, D. C.*	1865
Mendenhall, Thomas C	*Terre Haute, Ind.*	1887
Michelson, Albert A	*Cleveland, O.*	1888
Mitchell, Henry	*U. S. Coast Survey, Boston, Mass.*	1885
Mitchell, S. Weir	1524 *Walnut St., Philadelphia, Pa.*	1865
Morse, Edward S	*Salem, Mass.*	1876
Morton, Henry	*Hoboken, N. J.*	1874
Newberry, J. S	*New York City.*	——
Newcomb, Simon, U. S. N	*Washington, D. C.*	1869
Newton, H. A	*New Haven, Conn.*	——
Newton, John, U. S. A	*New York City.*	1876
Oliver, James E	*Ithaca, N. Y.*	1872
Packard, A. S	*Providence, R. I.*	1872
Peirce, Charles S	*U. S. Coast Survey, Washington, D. C.*	1877
Peters, C. H. F	*Clinton, N. Y.*	1876
Pickering, Edward C	*Cambridge, Mass.*	1873
Powell, John W	*Washington, D. C.*	1880
Pumpelly, Raphael	*Gibbs Ave., Newport, R. I.*	1872
Putnam, Frederick W	*Cambridge, Mass.*	1885
Remsen, Ira	*Johns Hopkins University, Baltimore, Md.*	1882
Rogers, Fairman	147 *S. Fourth St., Philadelphia, Pa.*	——
Rogers, William A	*Waterville, Me.*	1885
Rood, Ogden N	*New York City.*	1865
Rowland, Henry A	*Johns Hopkins University, Baltimore, Md.*	1881
Rutherfurd, Lewis M	175 *Second Avenue, New York City.*	——
Schott, Charles A	*Washington, D. C.*	1872
Scudder, Samuel H	*Cambridge, Mass.*	1877
Sellers, William	1600 *Hamilton St., Philadelphia, Pa.*	1873
Smith, Sidney I	*New Haven, Conn.*	1884
Trowbridge, John	*Cambridge, Mass.*	1878
Trowbridge, William P	*New York City.*	1872
Trumbull, J. H	*Hartford, Conn.*	1872
Verrill, A. E	*New Haven, Conn.*	1872
Walker, Francis A	*Boston, Mass.*	1878
Wood, Horatio C	1925 *Chestnut St., Philadelphia, Pa.*	1879
Wright, Arthur W	*New Haven, Conn.*	1881
Young, Charles A	*Princeton, N. J.*	1872

HONORARY MEMBERS.

Agassiz, Alexander	*Cambridge, Mass.*
Longstreth, Meirs F	*Derby, Pa.*
Lyman, Theodore	*Brookline, Mass.*

DECEASED MEMBERS.

	Date of death.
*Agassiz, Louis	Dec. 14, 1873
*Alexander, J. H	Mar. 2, 1867
*Alexander, Stephen	June 25, 1883
*Bache, Alexaner Dallas	Feb. 14, 1867
Baird, S. F	Aug. 19, 1887
Barnard, J. G	May 14, 1882
*Caswell, Alexis	Jan. 8, 1877
*Chauvenet, William	Dec. 13, 1870
*Clark, Henry James	July 1, 1873
*Coffin, James H	Jan. 6, 1873
Davis, Charles H	Feb. 18, 1877
Draper, Henry	Nov. 20, 1882
*Draper, John W	Jan. 4, 1882
Eads, James B	Mar. 8, 1887
Engelmann George	Feb. 11, 1884
*Frazier, John Fries	Oct. 14, 1872
*Gabb, William M	May 30, 1878
*Gilliss, James Melville	Feb. 9, 1865
*Gould, Augustus A	Sept. 15, 1866
Gray, Asa	Jan. 30, 1888
*Guyot Arnold	Feb. 8, 1884
*Hadley James	Aug. 1, 1864
*Haldeman, S. S	Sept. 10, 1880
Hayden F V	Dec. 22, 1887
*Henry Joseph	May 13, 1878
*Hitchcock, Edward	Feb. 27, 1864
*Holbrook, J. E	Sept. 8, 1871
*Hubbard, J S	Aug. 16, 1863
*Humphreys, A. A	Nov. 28, 1883
*Kirtland, Jared P	Dec. 10, 1887
*Lane, J Homer	— 1880
*Le Conte, John L	Nov. 15, 1883
*Mahan, D. H	Sept. 16, 1871
Marsh, G. P	July 23, 1882
*Meek, F. B	Dec. 21, 1877
*Morgan Lewis H	Dec. 14, 1881
*Norton, William A	Sept. 21, 1883
*Pourtales L. F	July 17, 1880
Rodgers, John	May 5, 1882
Rogers, Robert E	Sept. 7, 1884
*Rogers, William B	May 30, 1882
*Saxton, Joseph	Oct. 26, 1873
*Silliman, Benj Sr	Nov. 24, 1864
Silliman Benj. Jr.	Jan. 14, 1885
*Smith, J Lawrence	Oct. 12, 1883
*Stimpson William	May 26, 1873
*Strong, Theodore	Feb. 1, 1869
*Sullivant, W S	Apr. 30, 1873
*Torrey, John	Mar. 10, 1873
*Totten, J. G	Apr. 22, 1864
*Tuckerman, Edward	Mar. 15, 1886
*Warren, G. K	Aug. 8, 1882
Watson, James C	Nov. 23, 1880

	Date of death.
*Winlock, Joseph	Jan. 11, 1875
*Woodward, J. J., U. S. A	Aug. 17, 1884
Worthen, A. H	May 6, 1888
*Wyman, Jeffries	Sept. 4, 1874

FOREIGN ASSOCIATES.

Bunsen, Robert W	*Heidelberg.*
Airy, Sir George B	*Greenwich.*
Owen, Richard	*London.*
Burmeister, C. H. C	*Buenos Ayres.*
Struve, Otto von	*Pulkova.*
Adams, J. C	*Cambridge.*
Cayley. Arthur	*Cambridge.*
Clausius, Rudolph	*Bonn.*
Helmholtz, Baron H. von	*Berlin.*
Pasteur, Louis	*Paris.*
Stokes, G. G	*Cambridge.*
Sylvester, J. J	*Oxford.*
Hooker, Sir J. D	*Kew.*
Thomson, Sir William	*Glasgow.*
Auwers, Arthur	*Berlin.*
Bertrand, J. L. F	*Paris.*
Huxley, T. H	*London.*
Virchow, Rudolph von	*Berlin.*
Berthelot, M. P. E	*Paris.*
Chevreul, M. E	*Paris.*
De Candolle, Alphonse	*Geneva.*
Kölliker, Albert von	*Würzburg.*
Richthofen, F. von	*Berlin.*
Hofmann, A. W	*Berlin.*
Joule, James P	*Manchester.*

DECEASED FOREIGN ASSOCIATES.

Sir Wm. Rowan Hamilton.
Karl Ernst von Baer.
Henry Milne-Edwards.
Michael Faraday.
E. Elie de Beaumont.
Sir David Brewster.
G. A. A. Plana.
F. W. A. Argelander.
Friedrich Wöhler.
J. B. Dumas.
Michel Chasles.
Sir Roderick I. Murchison.
Victor Regnault.
H. W. Dove.
C. A. F. Peters.
Justus von Liebig.
Alexander Braun.
Joachim Barrande.
Adolphe Würtz.
Theodore von Oppolzer.
J. B. J. D. Boussingault.
G. R. Kirchoff.

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* Biographical notices have been presented of those designated by a *.

APPENDIX D.

REPORT ON OPIUM, 1887.

[CORRESPONDENCE.]

YALE COLLEGE,
New Haven, Conn., August 18, 1887.

SIR: I have the honor to transmit to you herewith a report on opium, made by a committee of the National Academy of Sciences, in compliance with the request contained in your communication dated May 3, 1887.

I will return by a later mail the remaining portion of the sample of opium analyzed.

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

Hon. C. S. FAIRCHILD,
Secretary of the Treasury.

TREASURY DEPARTMENT,
Washington, D. C., May 3, 1887.

SIR: I transmit to your address, under another cover, a sample taken from a lot of prepared opium seized at Port Huron, Mich., on the ground that it had been smuggled.

With a view of determining the precise character of this article, it is deemed important that it should be analyzed to ascertain what percentage of morphia it contains.

Will you kindly cause such analysis to be made, under the direction of the National Academy of Sciences, and inform me of the result at your earliest convenience? It is requested that such portion of the sample as is not consumed in the analysis be returned.

The package is marked in red figures number 23,133, and in black, 5,701*e*.

Respectfully, yours,

C. S. FAIRCHILD,
Secretary.

Prof. O. C. MARSH,
President National Academy of Sciences,
Yale College, New Haven, Conn.

NATIONAL ACADEMY OF SCIENCES,
New Haven, Conn., May 4, 1887.

SIR: I inclose a copy of a letter from the Secretary of the Treasury, requesting a second investigation of opium to be made by a committee of the National Academy of Sciences, and I should be glad to have you act as chairman of this committee.

The province of the Academy is not to conduct a technical examination merely, but especially to bring out the scientific principles involved in the investigation, and in this spirit, I wish the work to be undertaken.

Your associates on this committee will be Prof. George F. Barker, of the University of Pennsylvania, and Prof. Charles F. Chandler, of Columbia College, New York.

Hoping you will be able to take charge of this work, I remain,

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

Prof. IRA REMSEN.

REPORT.

Prof. O. C. MARSH,
President of the National Academy of Sciences:

SIR: The committee appointed by you to examine and report upon a specimen of opium submitted by the Secretary of the Treasury, herewith present their report:

In view of the fact that a number of methods for the estimation of the morphine in opium have been described, it seemed to the committee desirable to make a few comparative experiments on these methods, in order that they might be in a position to form an independent judgment regarding the relative value of these methods. Accordingly, the services of Mr. I. H. Kastle, of the Johns Hopkins University, were engaged, and the experimental part of the inquiry was made by him under the direction of the committee.

The methods examined were:

1. That of the United States Pharmacopœia.
2. Flückiger's method.
3. Squibb's modification of Flückiger's method.
4. Stillwell's modification of the Flückiger-Squibb method.
5. The so-called "Helfenberg method" devised by Dietrich.

In the Pharmacopœia method, the opium is triturated with lime and water, and water is then added to make up a certain volume. After standing for half an hour, enough of the liquid is filtered to make 50 ic centimeters. To this, 5 cubic centimeters alcohol and 25 cubic timeters ether are added, and the mixture shaken. A small quan- of ammonium chloride is then added, and the mixture, after being shaken, is set aside for twelve hours. The details of the filtering ess need not be given here.

lückiger's method* dispenses with the lime. In other respects it is unlike the method of the Pharmacopœia. In each estimation, 80 ns water are used, and for the precipitation of the morphine, only grams of the filtrate are taken, the assumption being made that portion contains just half the morphine.

uibb† found that the assumption that half the morphine is con- ed in 42.5 grams of the filtrate, when the method of Flückiger is l, is not justifiable; and he describes in detail‡ a modification of the hod of Flückiger by which all the filtrate is used, and great care is n to secure complete extraction of the morphine. Squibb objects e methods which depend upon the use of lime, because they do not oughly exhaust the morphine, and to the use of an aliquot portion e filtrate, for the reason stated above.

illwell§ has further modified the method of Flückiger. He recom- ds for washing the precipitate of morphine the use of two liquids, h he calls "morphiated spirit" and "morphiated water." The first de "by mixing one part of ammonia solution, specific gravity 0.880, twenty parts of alcohol, and saturating with morphia." The second, saturating water by long shaking with excess of morphia." The ct of using these solutions is to prevent loss of morphine during the ing.

ietrich's method|| is as follows: Six grams opium is macerated in a ar with 6 grams water. This is brought into a flask, and the liquid ed with water to 54 grams. The whole liquid is macerated with ent agitation for an hour, and then filtered. To 42 grams of the te, 2 cubic centimeters normal ammonia are added, and the liquid ed at once. Thirty-six grams of this filtrate correspond to 4 grams m. This quantity is mixed with 10 grams ether, and 4 grams nor- ammonia added. After five to six hours, the ether layer is poured n to a filter, and to the opium solution, 10 grams ether added. After is poured off, the aqueous solution is poured upon a filter, and the and filter washed with 5 cubic centimeters water saturated with r.

n applying these methods to an average specimen of opium obtained

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'arm. Journ.: Transactions [3], 10, p. 254.

phemeris, Vol. I, p. 12.

oc. cit., pp. 14–21.

merican Chemical Journal, Vol. VIII, p. 295.

harm. Centralhalle, No. 43, 1886; Helfenberger Annalen, 1886, 40; and Pharm. ralhalle, No. 21, 1887.

in the market, taking all the precautions demanded by the original directions, the following results were reached:

TABLE I.

Percentage morphine found.

Method.				
Stillwell.	Squibb.	Flückiger.	Pharmacopœia.	Dietrich.
11.86	11.86	8.14	16.12	10.90
11.7	11.77	8.56	16.19	10.72
11.53	11.89	....	....	....
11.38	....	....	....	....
11.41	....	....	....	....

On comparing the method of Stillwell with that of the Pharmacopœia, using another specimen of opium, the following results were obtained:

TABLE II.

Percentage morphine found.

Method.	
Stillwell.	Pharmacopœia.
10.30	15.14
....	15.74

The marked difference between these results led to a further examination of the precipitate obtained by the Pharmacopœia method, which showed that it was far from pure morphine. When treated with hot alcohol, a black, insoluble residue was left, and this gave none of the tests for morphine. On subtracting the residue in each case from the total precipitate obtained, and calculating the remainder as morphine, the percentage of morphine in the four experiments which, by the Pharmacopœia method, showed 16.12, 16.19, 15.14, and 15.74 per cent. morphine, became (1) 9.65, (2) 9.73, (3) 9.08, and (4) 9.17. On comparing these results with those obtained by Stillwell's method, it will be seen that they are considerably lower.

In Stillwell's method, the precipitate first obtained is purified by treatment with hot alcohol. This dissolves all the morphine, leaving the insoluble organic matter and meconate of lime. It is, therefore, certain that what is taken into account as morphine is this substance. In Squibb's method, this precaution is not taken. The difference between the results obtained by the two methods is, however, not large, as the error due to the presence of impurities in the precipitate is partly compensated for by loss due to the method of washing.

found that the time required for making estimations by Stillwell's
an be materially shortened, without interfering with the accu-
triturating the opium at first with a small quantity of water in
Three estimations were made by the method as described by
These gave, respectively, 11.47, 11.53, and 11.38 per cent.
One estimation made with the same opium, first triturating
described, gave 11.41 per cent. morphine.

been repeatedly shown by others, the method of Flückiger
ults which are too low. Our experiments show, further, that
s method does not give all the morphine contained in some
of opium, particularly such as yield a magma with water
ters with extreme slowness. The results recorded in Table I
0.7 per cent. lower than those obtained by Stillwell's method.
ering all the facts, we conclude that of the methods for the
n of opium thus far described, that of Stillwell is in every way
satisfactory, and we also find that the time necessary for an
n by this method may be materially shortened by slightly mod-
e first process of extraction, as follows:

te the opium in a porcelain mortar with 25 cubic centimeters
ntil a uniform paste is formed. Then bring this into a flask
ut 75 cubic centimeters water, cork tightly, and shake vigor-
half an hour; filter and proceed as recommended by Stillwell.

g thus reached a conclusion in regard to the value of the avail-
hods, we made three estimations of morphine in the sample of
bmitted by the Secretary of the Treasury, using the Stillwell
with the slight modification above suggested. The results ob-
e given below:

tage of morphine found in the specimen of opium submitted by
tary of the Treasury, 12.21, 12.09, and 12.19 per cent.; average
cent.

nount of water in the specimen was also estimated, and found
periments to be 18.81 and 18.67 per cent.

ium examined is a thick, black, semi-fluid mass.

tfully submitted.

IRA REMSEN, *Chairman.*
GEORGE F. BARKER.
CHARLES F. CHANDLER.

MORE, *August* 16, 1887.

APPENDIX E.

REPORT ON SUGAR DETERMINATIONS.

[CORRESPONDENCE.]

Yale College,
New Haven, Conn., December 30, 1887.

Sir: I have the honor to transmit to you herewith a report on certain standard quartz plates used in the classification of sugars for duty, made by a committee of the National Academy of Sciences, in compliance with the request contained in your communication of June 17, 1887.

Very respectfully,

O. C. Marsh,
President of the National Academy of Sciences.

Hon. C. S. Fairchild,
Secretary of the Treasury.

Treasury Department,
Washington, D. C., June 17, 1887.

Gentlemen: Certain questions connected with the classification of imported sugars are now under consideration by this Department. It becomes necessary that three standard quartz plates used by appraisers in determining the saccharine strength of sugars whereby its classification for duty is made, be tested with a view to ascertain their exact measurement, angle, and ray. I will thank you to inform me if the necessary test can be made by your Academy, and, if so, upon receipt of your reply, the plates will be forwarded to such address as you may indicate.

Respectfully, yours,

C. S. Fairchild,
Secretary.

The National Academy of Sciences,
Washington, D. C.

Yale College,
New Haven, Conn., June 28, 1887.

Sir: Your communication of June 17, inquiring if the National Academy of Sciences would undertake the examination of the standard quartz plates used in the classification of sugars for duty, reached me to-day.

In reply, I have the honor to say that the Academy will undertake the proposed investigation, and I have appointed Prof. A. W. Wright, of Yale University, to superintend the work. If you will have the plates forwarded to him at New Haven, Conn., the investigation will be commenced without delay.

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

Hon. C. S. FAIRCHILD,
Secretary of the Treasury.

YALE COLLEGE,
New Haven, Conn., June 28, 1887.

SIR: I inclose a communication from the Secretary of the Treasury, dated June 17, 1887, inquiring if the National Academy of Sciences would undertake the examination of the standard quartz plates used in the classification of sugars.

I have informed the Secretary that the Academy will undertake the proposed investigation, and I have requested him to send the plates to you, whom, as chairman of the committee, I have appointed to superintend the work.

Your colleagues in this investigation will be Prof. Edward S. Dana, and Prof. Charles S. Hastings of Yale College, and it will be a favor to the Department if you can complete the examination at an early day.

The proper province of the National Academy is not merely to make a technical examination in a case of this kind, but, likewise, to bring out the scientific principles involved, as a basis for future use, and with this idea in view, I hope you will be able to undertake the work.

Very respectfully,

O. C. MARSH,
President of the National Academy of Sciences.

Prof. A. W. WRIGHT,
Yale College.

NEW HAVEN, CONN., *December* 29, 1887.

SIR: The committee appointed by the president of the National Academy of Sciences, at the request of the honorable Secretary of the Treasury, to examine certain quartz plates used in the laboratories of the United States appraisers' offices in Boston, New York, and Philadelphia, respectfully report that they have completed the examination and *measurement of these plates*, and submit herewith the results obtained by them, together with an account of the methods employed, and of the instruments and processes made use of in the different stages of the work.

Very respectfully, your obedient servant,

ARTHUR W. WRIGHT, *Chairman.*

Prof. O. C. MARSH,
President of the National Academy of Sciences.

REPORT.

The committee have made an examination of six quartz plates sent to the chairman by order of the Secretary of the Treasury, from the appraisers' offices of Boston, New York, and Philadelphia. The plates are used in adjusting the saccharimeters employed in the determination of the saccharine strength, or degree of purity, of imported sugars, upon which depends the classification of such sugars into different grades for duty. The use of the saccharimeter is founded upon the property of cane sugar, that when a ray of plane-polarized light is passed through a solution of it, the plane of polarization of the ray is turned to the right, and the angle through which the plane is turned in a column of the solution of given length is proportional to the strength of the solution, or, in other words, to the amount of sugar contained in it. The same property is found in quartz, for a ray transmitted through it in the direction of the crystalline axis, and the variety of quartz known as right-handed, turns the plane of polarization to the right, and the amount of the turning for light of different wave-lengths, or the dispersion, is very nearly the same as for cane sugar, and is proportional to the thickness of the crystalline plate. Each plate bears a number representing the exact percentage which a column of sugar solution of a certain length bears to a standard sugar solution of the same length under certain standard conditions, when it rotates the plane of polarization to the same degree as the quartz plate. Hence, when placed in the saccharimeter, it may be, and is, used to determine the exactness of the scale of the instrument, or for adjusting it when not properly set. As an error in the setting affects all subsequent measurements made with the instrument, the importance of a correct determination of the exact value of the quartz relatively to a standard sugar solution is evident.

I.—DESCRIPTION OF THE QUARTZ PLATES.

Of the six quartz plates, three were received by the committee early in July, and these bore the numbers 54.5, 99.1, and 99.1–2. During the first week of September, three others were received, bearing the numbers 50.8, 96.0, and 98.8. In the following paragraphs, they are designated by the numbers simply, and in the order of their numerical value.

No. 50.8.—This was a portion of a broken plate, and was in three fragments, the largest of which comprised the central portion of the plate, and was amply sufficient for the examination. It was simply mounted loosely in an ordinary sugar tube. The number was marked upon the end of this tube.

No. 54.5.—A circular plate, 15 millimeters in diameter, mounted in a blackened brass tube, 30 millimeters in diameter and 38 millimeters long. At about the middle of one side of the tube, a short brass pin, or plug, was inserted, the mark number being engraved in the metal near it.

No. 96.0.—A circular plate, 15 millimeters in diameter, mounted in a polished and lacquered brass tube, about 125 millimeters long, and having at each end a flange of the same diameter as that of an ordinary sugar tube, for supporting it in the proper position in the saccharimeter. The number is marked in the flat surface at the end of the tube where the plate is inserted.

No. 99.1.—A circular plate, 15 millimeters in diameter, not mounted. The value 99.1 is not marked upon the plate, but was communicated to the committee in a letter from the appraiser.

No. 99.1-2.—A circular plate, mounted like No. 96.0, having substantially the same dimensions, and marked upon the end surface in the same manner.

No. 98.8.—A circular plate of the same size as the preceding, mounted in a rather heavy brass tube, which was polished and lacquered. The tube, 30 millimeters in diameter and about 125 millimeters long, has a pin on one side, like No. 54.5. The mark is scratched upon the end surface of the tube.

II.—THICKNESS OF THE PLATES.

The thickness of each of the quartz plates was measured with a spherometer with great care. Independent series of measures were made by two members of the committee with substantially identical results. They are given herewith, and may be considered accurate to the thousandth part of a millimeter. They represent the thickness at the center of the plate, which is approximately the mean thickness of the whole plate:

	Millimeters.
No. 50.8	0.813
No. 54.5	0.875
No. 96.0	1.537
No. 98.8	1.576
No. 99.1	1.589
No. 99.1-2	1.585

The rotation of the plane of polarization by a quartz plate of given thickness, cut perpendicularly to the axis, has been determined with great precision by several different physicists. Mascart,[*] from a series of very accurate measures, deduces the value 21°.73, for the angle of rotation of the plane of polarization for the rays from a sodium flame, for a thickness of 1 millimeter, and states that this value is correct to one part in two thousand, or one unit in the last decimal place given, at the temperature of 15° C. Govet and Sarasin[†] give the value 21°.727, for 20° C. Von Lang[‡] found the value 21°.727, at about 21° C. These observations were made with long columns of quartz, and the results may be accepted as correct. The number 21°.73 may be taken as the most accurate value for 20° C. The direction of the ray in all these experiments was very accurately parallel to the crystalline axis.

For thinner plates, of from 1 to 2 millimeters in thickness, the commonly accepted value, for 20° C., is 21°.67 per millimeter,[§] which is founded upon the determination made by a number of different observers. The difference is perhaps due to a change in the constitution of the substance of the crystal near the surface, made in polishing, or, more probably, to the fact that these plates will rarely, if ever, accurately fulfill the conditions of perfect parallelism of the surfaces and perpendicularity of the crystalline axis. The number is probably too small, but, as will be mentioned further on, these thin plates give different values according to their position.

Were the rotation of the ray strictly proportional to the thickness of the plate, its value could be readily deduced from the measurement of the thickness by the use of the above data. As they were found, however, to give results varying among themselves, as well as less accurate than those obtained subsequently by a different process, this method was abandoned as unsuited to the requirements of the problem.

III.—ROTATIONS.

For the measurement of the rotation of the plane of polarization the following instruments were used: (1) A pair of Nicol's prisms, one of which was stationary, and the other mounted in a graduated circle, the quartz plate being placed between the two, perpendicular to the line of collimation. The rotation was measured by the extinction of the light, or by the use of a bi-quartz or bi-selenite plate as an indicator. (2) A Laurent polarimeter, or saccharimeter, large model, having a circle 184 millimeters in diameter, graduated around the entire circumference, reading directly by a vernier to intervals of two minutes of arc, and readily allowing measurements to one minute of arc. The circle was investigated for the determination of its errors, and found to be perfect within the limits of possible accuracy of reading. (3) A polaristrobometer of Wild, reading by a vernier directly to tenths of degrees, and by estimation readily giving differences of one-twentieth of a degree. The light of the sodium flame was employed in all the observations. The values for the rotations determined by the different methods, though agreeing fairly well with each other as respected any particular plate, proved to vary in a manner different from the thickness when the different plates were compared with each other. It was also found that the same plate gave different results, according to its position in the instrument, and, further, that the values obtained were dependent, in some measure, upon the instrument employed. This was found to be the effect of defects in the plate. A plate cut perpendicular to the axis, and with surfaces accurately parallel and plane, when placed perpendicular to the incident ray, could give but one value for the rotation angle. None of the plates examined fulfilled these two conditions accurately, and in some of them, the divergencies were considerable. In all of them, the surfaces are inclined at a small angle to each other, so that the thickness in different parts of the same plate is perceptibly different. In the case of the plate 50.8, the difference amounted to some six one-thousandths of a millimeter, or about eight-tenths of 1 per cent. of the whole value. In the plate 98.8, it amounted to nearly twelve one-thousandths of a millimeter, or nearly the same percentage of the total thickness, as in the case of 50.8. In 96.0, it was four one-thousandths of a millimeter.

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[*] Annales Sci. de l'École Normale. Deuxième série. Tom. I, p. 209.

[†] C. R., Tom. 83, 1876, p. 819.

[‡] Sitzungsb. Akad. der Wissenschaften, Wien, Bd. LXXIV, p. 213.

[§] Landolt. Das Opt. Drehungsvermögen Organ. Substanzen, p. 41.

As the rotation is proportional to the thickness, it is evident that the value of the rotation angle would be different in different parts of the plate, and that in all instruments using a divided field for the indicator, as a bi-quartz, or a half-shadow arrangement, the value would be affected by the position of the thicker and thinner portions relatively to the two halves of the field.

Another cause of variation is to be found in the fact that the crystalline axis of the plate does not lie in a line perpendicular to the surface, and thus is not parallel to the ray traversing the plate. The effect of this is, that the ray issuing from the crystal is no longer plane-polarized, but is polarized elliptically. This causes a variation of the rotation of such a character that it will increase it in one position of the plate and diminish in another position, such as would be found by turning the plate 90° about its axis. All the plates showed this effect somewhat, but in 99.1 and 99.1–2 it was very slight. It was especially marked in 96.0.

As in all cases, both the defects mentioned above co-existed in the same plate, though in different degrees, the results found for the separate plates do not follow the same law for the various positions of the plate relatively to the plane of polarization of the incident ray, and, as remarked above, the value obtained for the same position of a plate would vary somewhat with the instrument employed for the measurement, especially in the case of light polarized elliptically.

For these reasons, the value of the rotation obtained in any single case would be without significance, unless referred to the position of the plate, and the mean value of the rotation for a particular plate would be of little practical use in determining its value in the saccharimeter as it is ordinarily used, since it would necessitate for its application the making of numerous series of tedious measurements.

IV.

In consequence of the want of satisfactory agreement between the results obtained from the measurements of the thickness, and those derived from the rotation, dependent upon the variations in the form of the plates, a method was adopted, which, though requiring a great number of laborious determinations for each plate, had the advantage of furnishing values under conditions similar to those which prevail in their practical use with the saccharimeter, and of indicating a means of securing for each one a constant and accurate value. A saccharimeter of the same form as that used in the laboratories of the United States appraisers' offices was employed, which had been constructed in the atelier of Dr. Scheibler, of Berlin. As the value of the divisions of the scale of the instrument and its adjustment must be accurately known, a direct determination was made of different points of the scale, by comparison with the values of columns of different lengths and different degrees of concentration of solutions of pure sugar in distilled water.

(1) *Preparation of pure sugar.*—A quantity of crystallized sugar candy was dissolved in about one-half its weight of distilled water. and the hot solution was filtered. Absolute alcohol was added to the sirup thus obtained, and the mixture stirred until precipitation was complete. A small quantity of distilled water was then added to dissolve the finer portions of the precipitate, and after a very brief interval, the liquid was poured off, leaving the sugar in a finely granulated condition, facilitating thorough washing. This was then transferred to a clean filter, and washed, first with alcohol containing a small proportion of water, and finally with copious affusions of absolute alcohol. After draining the sugar was thoroughly dried at a gentle heat.

(2) *The sugar flasks.*—Four sugar flasks, of the kind ordinarily used and of the nominal capacity of 100 cubic centimeters, were used. Their actual capacity when filled to the mark with distilled water was determined by means of the balance, the weighing being corrected for the reduction to a vacuum, and for the temperature of the water. The values found showed that the flasks had been graduated without applying these corrections. The capacity of the flasks having been thus carefully determined, the amount of sugar to be used with each one was computed, applying the reduction to the weight in a vacuum, and on the basis of 26.048 grams of sugar to 100 cubic centimeters of distilled water at 17.5° C. The weight thus determined, or a suitable fraction of it, was used in the subsequent experiments.

(3) *The sugar tubes.*—The tubes accompanying the instrument were found to be inaccurate, the 200-millimeter tube being too long by about

0.25 millimeters, and the 100-millimeter tube having its ends oblique to the axis, and not parallel. The latter was of brass, and was remedied by cutting out the brass tube and substituting one of glass, and then both tubes were carefully ground to the accurate length of 200 millimeters and 100 millimeters, respectively, by comparison with an accurate standard meter bar, and great care was taken to make the ends flat and perpendicular to the axis.

(4) *Determination of the scale values of the Scheibler instrument.*—Standard solutions having been prepared, under the conditions above described, the tubes were filled, and the values determined with the saccharimeter, at a temperature of 20° C., or one varying from this so slightly as to make correction unnecessary. The scale of the instrument was found to be sensibly correct at 100.0; at 50.0, it read too high by 0.08 division, and at 37.5, too high by 0.05 division. These corrections were applied in the measurements of the quartz plates. Other points of the scale were verified in like manner. The results for the tubes in the different cases were checked by measuring the rotations with the Laurent instrument, and computing the corresponding values, with a very satisfactory agreement in each case.

V.—MEASUREMENTS AND RESULTS.

The results obtained in the previous work had shown very clearly that the value of a quartz plate is a function of its position relatively to the plane of polarization of the incident light. It became necessary, therefore, to determine whether the number accompanying each plate fell within the range of the variations in its value in different positions. The method of procedure was as follows: The tube holding the plate was placed in the instrument, the quartz being toward the light, that is, away from the observer. The pin, or the number stamped or engraved on the tube, served as a mark for the position. The mark being at a certain point, a series of readings was made, never less than five, often ten or twenty; then the tube was turned about its axis through an angle of 45 degrees, and the operation repeated. The value of the plate was thus derived from a very large number of readings. The means of the results thus obtained were then used to plot a curve showing the variation, and this was used to determine the proper position of the tube and quartz plate in actual use. The results obtained with each plate are given in the following paragraphs. It is to be understood that in every case, the tube carrying the quartz plate is so placed that the latter is toward the end of the instrument at which the light enters.

50.8.—This is the broken plate, and it is understood that it is no longer in use. From its fragmentary condition, the proper position is not easily assigned, but if the line drawn between the opposite angles in the direction of its greatest length is placed vertically, and then the top is turned about 45 degrees toward the left of the observer, it will have very nearly the value 50.8. The plate is strongly wedge-shaped, and its value may vary from about 50.6 to nearly 51.0 in different positions.

54.5.—This plate has the value 54.5 when the pin upon the tube is at the top, that is, so that the diameter of the tube passing through the pin is vertical. This plate is also very variable, the range being two-tenths of a scale division when it is turned through 180 degrees about its axis.

96.0.—This plate has the value 96.0 when placed with the mark at the top, and turned about 20 degrees to the right of the observer. It will have the same value if the tube is reversed, with the quartz plate nearest the observer, and the mark at the top in a vertical diameter. This plate has well-marked elliptical polarization, showing that it is not cut perpendicularly to the crystalline axis, and its value may vary through a range of some two and a half tenths of a scale division, for 180 degrees change of position, from 95.95 to nearly 96.2.

98.8.—This has the value 98.8 when placed with the pin at the top of the tube, in a vertical diameter. Its variation is less than the preceding, amounting to about one and a third tenths of a scale division, for 180 degrees change of position, or from 98.67 to 98.8.

99.1.—This plate was not mounted. The mark used in fixing its position is the larger of the two nicks at the edge, and it must be placed with the side having this nick nearest the light. Some minute marks made with a diamond near it will serve to distinguish it. The plate should be placed with the mark at the top, and turned about 20 degrees toward the right of the observer, from a position in a vertical diameter. The number 99.1 is the minimum value of the plate, and it may change to a little more than 99.2 as the plate is turned 180 degrees around its axis. The mean value of the plate for all positions is very nearly 99.16.

99.1-2.—This plate has the value 99.15, corresponding with the marked value, when the mark is placed at the bottom, in a vertical diameter. This is very nearly its maximum value. With the mark at the top, its value is 98.92, which is nearly the minimum rate. The mean value of the plate for all positions is nearly 99.05.

The values above given are for the temperature of 20° C., the standard temperature for observations of this kind. If the quartz plates are used at temperatures differing considerably from this, corresponding corrections must be applied.

Respectfully submitted.

ARTHUR W. WRIGHT, *Chairman*,
EDWARD S. DANA,
CHARLES S. HASTINGS,
Committee.

APPENDIX F.

REPORT ON THE INTERNATIONAL ASTRONOMICAL CONGRESS, HELD IN PARIS, APRIL, 1887.

[CORRESPONDENCE.]

THE NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., March 28, 1887.

SIRS: Your invitation, dated Paris, October 15, 1886, requesting me to appoint a delegate from the National Academy of Sciences to the International Astronomical Convention to be held at Paris, April, 1887, was duly received.

In response to this invitation, I have the honor to inform you that I have appointed Prof. C. H. F. Peters, director of the Observatory of Hamilton College, Clinton, N. Y., as delegate to represent the National Academy of Sciences at that convention.

I remain, with high respect, very truly, yours,

O. C. MARSH,
President of the National Academy of Sciences.

Messrs. BERTRAND and VULPIAN,
Perpetual Secretaries of the Academy of Sciences, Paris.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C. March 28, 1887.

SIR: I hereby appoint you the delegate to represent the National Academy of Sciences at the International Astronomical Convention to be held at the Observatory of Paris, beginning April 16, 1887, and this letter will be your credentials confirming your appointment.

I have already informed the secretaries of the Academy of Sciences in Paris of your selection as delegate, and trust you will be willing to represent our Academy, and give the convention the benefit of your wide experience in the subjects to be considered on that occasion.

Very truly, yours,

O. C. MARSH,
President of the National Academy of Sciences.

Prof. C. H. F. PETERS,
Director of the Observatory of Hamilton College.

HAMILTON COLLEGE,
Clinton, N. Y., January 3, 1888.

SIR: I have the honor to inclose herewith my report on the International Astrophotographical Congress, held in Paris, April, 1887.

Yours, respectfully,

C. H. F. PETERS,
Delegate.

Prof. O. C. MARSH,
President of the National Academy of Sciences.

REPORT.

The Congress of Astronomers, called by invitation of the French Academy of Sciences, for considering the realization, by means of photography, of a chart of the heavens, convened in the "grande salle" of the National Observatory at 2 p. m., April 16, and was opened under the presidency of Monsieur Flourens, Minister of Foreign Affairs.

There were present in all fifty-seven members; thirty-six from foreign countries, and twenty-one from France. The latter number was composed of twelve delegates from the Academy of Sciences, viz: Messrs. Bertrand, Bouquet, Cornu, Delahaye, Faye, Fizeau, Janssen, Lœvy, Mouchez, Perrier, Tisserand, Wolf; three directors of provincial observatories, viz: Baillaud, of Toulouse; Rayet, of Bordeaux; Trépied, of Algiers; three representatives of the council of the Paris Observatory, viz: Vice-Admiral Clouet, Colonel Laussedat, and Mr. Liard, director of higher instruction; further, the Messrs. Paul Henry and Prosper Henry, who as assistants in the Paris Observatory have carried star photography already to a high degree of perfection, and Mr. P. Gautier, the renowned constructor of instruments of precision.

The names of the foreign members, representing fifteen different nationalities, may here follow in alphabetical order:

A. Auwers, Berlin.
H. G. van de Sande Bakhuijzen, Leiden.
F. Beuf, La Plata (Buenos Ayres).
W. H. M. Christie, Greenwich.
A. A. Common, London.
L. Cruls, Rio de Janeiro.
A. Donner, Helsingfors.
N. C. Dunér, Lund.
J. M. Eder, Vienna.
W. L. Elkin, N. Haven, Conn.
F. Folie, Brussels.
E. Gautier, Geneva.
D. Gill, Cape of Good Hope.
H. Gylden, Stockholm.
B. Hasselberg, Pulkowa.
J. C. Kapteijn, Groningen.
E. B. Knobel, London.
A. Krueger, Kiel.
O. Lohse, Potsdam.
Oom, Lisbon.
J. A. C. Oudemans, Utrecht.
C. F. Pechyle, Copenhagen.
S. J. Perry, Stonyhurst.
C. H. F. Peters, Clinton, N. Y.

C. Pujazon, San Fernando.
I. Roberts, Liverpool.
H. C. Russell, Sydney, N. S. Wales.
E. Schoenfeld, Bonn.
A. Steinheil, Munich.
O. Struve, Pulkowa.
P. Tacchini, Rome.
J. F. Tennant, London.
T. N. Thiele, Copenhagen.
H. C. Vogel, Potsdam.
E. Weiss, Vienna.
A. G. Winterhalter, Washington, D. C.

After some words of greeting by Mr. Bertrand, the standing secretary of the Academy of Sciences, Mr. Flourens addressed the Congress, bidding welcome in the name of the Government of the French Republic. To this address, Mr. Struve responded for the members. Admiral Mouchez likewise bade welcome on behalf of the Observatory, of which he is the director.

Upon proposition of Mr. Flourens, Admiral Mouchez was voted honorary president, and Mr. O. Struve, of Pulkowa, acting president. Meanwhile, a preliminary programme, prepared by early-arrived members in caucus on the preceding days, had been distributed, and the discussion began.

In this first general session, the following principles were agreed upon:

(1) The progress made in astronomical photography demands that the astronomers of our time undertake in common the description of the heavens by astrophotographical means.

(2) This work is to be done at stations to be selected, with instruments that, in their essential points, ought to be identical.

(3) The aim is (*a*) to make a general photographical chart of the heavens for the present epoch, and to obtain the data which shall permit fixing the positions and the magnitudes of all the stars down to a certain class with the greatest possible precision; (*b*) to provide the best means for utilizing, for the present epoch as well as for the future, the data furnished by the photographical process.

The Congress nominated thereupon a "comité technique" for considering and making a report upon the construction and the dimensions of the instruments that should be employed, and upon the limit of photographic magnitudes that should be obtained. The following members were elected to constitute this committee, viz: Auwers, Bakhuijsen, Christie, Common, Dunér, Fizeau, Gill, Paul Henry, Janssen, Kapteijn, Bœvy, Peters, Rayet, Roberts, Struve, Tacchini, Thiele, Vogel, Weiss. I wish to state here that the original list, made up by the caucus, showed the name of Mr. Rutherfurd (the caucus having received the information that Mr. Rutherfurd would be delegated by the National Academy), for which, on the proposition of Mr. Gill, mine was substituted. It is, indeed, to be regretted that the representative men of astrophotographical science in the United States, Messrs. Rutherfurd and Pickering, were not present.

A meeting of the technical committee was held on Monday, April 19, and the matter that naturally first offered itself for consideration was the question, whether reflecting telescopes or refractors should be used. With the former kind of instruments, the most excellent pictures have been produced (as, for example, the unsurpassed picture of the nebula of Orion by Mr. Common), and reflectors have the advantage of being free from chromatic aberration. But the difficulty of keeping the specula always of good polish, and the almost impossibility of giving and maintaining the reflecting power equal for all the co-operating instruments, led to the adoption, by unanimity, of the refractor. Thereupon, the limit of stellar magnitude and the dimension of the telescopes were discussed by the technical committee, whose recommendations were accepted by the general session, on the following day, in the following terms:

(1) The instruments to be employed shall be refractors throughout.

(2) The stars shall be photographed to the fourteenth magnitude, inclusive, with the reserve that the photometric value of this magnitude shall be fixed definitely at a future occasion.

(3) The aperture of the objective shall be 0.33 millimeters (about 13 inches), and the focal distance about 3.43 millimeters (135 English inches), so that 1 minute of arc be represented approximately by 1 millimeter.

In the same general session, it was resolved to divide into two sections: the astronomical and the astrophotographical.

The conclusions arrived at in the sections were reported in the general session of Saturday, April 23, and the points, as they were adopted, are the following:

A.—RESOLUTIONS OF THE ASTROPHOTOGRAPHICAL SECTION.

(1) Observers are at liberty to have their object glasses made by any artist they desire, provided the general conditions prescribed by the Congress be fulfilled.

(2) The corrections for aplanetism and achromatism of the object glasses shall be calculated for rays near to the ray G of Fraunhofer.

(3) All plates shall be prepared after one and the same formula, to be determined nearer hereafter.

(4) These plates must be examined always in regard to their sensibility for the different rays.

(5) Questions in regard to preservation and reproduction of the negatives can not, in the opinion of the section, be solved at present, and should be referred to a special committee.

(6) The same is the case in regard to the determination of the photographic magnitudes of the stars.

(7) (Additional) The resolution 2, above, regarding the aplanetism and the achromatism of the objectives, means to say that the minimum

focal distance be that of a ray near G, with the view to attain the greatest sensibility of the photographic plates.

(8) The objectives are to be so constructed that of the field at least 1° from the center can be utilized.

(9) In order to guard against spurious stars and little spots that might exist on the plates, two series of negatives should be made for the whole heavens.

(10) The two series to be made in such a way that the image of a star at the edge of a plate in the first series be as near as possible at the center of a plate in the second series.

B.—RESOLUTIONS OF THE ASTRONOMICAL SECTION.

(1) Besides the two photographs that are to give all the stars to the fourteenth magnitude, inclusive, there is to be made a series with shorter exposition, in order to secure a greater precision in measuring micrometrically the positions of the reference stars, and to permit the construction of a catalogue.

(2) The supplementary negatives, serving for the construction of the catalogue, ought to include all the stars of the eleventh magnitude.

(3) Each photographic plate, serving for the formation of the catalogue, must be accompanied by all the data necessary for its orientation and scale value, and as much as possible these data are to be found inscribed upon the plate itself.

Each plate of this kind to carry a well-centered copy of a system of reference lines, derived from a reticle, and serving to eliminate the errors that may originate from a later deformation of the sensitive layer.

(4) These auxiliary reference lines in the negatives that are taken for the formation of the chart are reduced to a minimum.

(5) The tubes of the photographical instruments should be constructed of a metal the most favorable for obtaining an invariable focal plane, and should carry a graduation for determining and regulating the position of the plates.

(6) The selection of the stars of reference is left to an executive committee.

(7) To the same committee is left, also, the question about the methods of measuring, and of converting the measured figures into right ascensions and declinations for the epoch of 1900.

This committee will have to occupy itself in the first place with the study and application of the measuring instruments that can give at pleasure rectangular or polar co-ordinates, etc.

(8) The fitting together of the plates will be obtained in conforming to the resolution adopted by the astrophotographical section.

In the same general session, as preliminary to the distribution of the work, a rather informal survey was made to ascertain which observatories might be counted upon as co-operative in photographing the chart. Very few only were ready, of course, to give positive assurance, as the appropriation for the apparatus depended upon the respective governments. In this respect, mention must be made of the liberal act of the Emperor of Brazil, who, in the same days when the Congress was in session, notified Mr. Cruls by cablegram that the observatory of Rio de Janeiro was to participate, whatever the cost of the instruments. Upon inquiry by one of the members, Messrs. Trépied and Lœvy gave the information that the price of a telescope of the kind required by the resolution would be about 40,000 francs ($8,000), and the working expenses were estimated at not exceeding 2,000 francs ($400), apart from the employment of an assistant.

The general principles and the ways and means to be recommended for securing uniformity in the international enterprise being thus agreed upon by the Congress, it seemed now desirable to elect a permanent executive committee, partly for arranging certain details that needed still some preparatory investigation, and partly for exercising a certain supervision, reporting annually the progress of the work, maintaining intercourse with the different observers, and giving advice when requested. If, during the next year, as is at least not impossible in the process of photographing, some further notable improvements should come to light, the committee would have to see to it that they be adopted.

In order to make apparent, in some way, the vastness of the undertaking, it will not be amiss to remark here that, assuming the field of the telescope to be about one degree and a half, over sixty thousand plates will be required for re-producing the entire celestial vault in the three series of photographs proposed by the Congress. If, then, twenty observatories be participating in the work, and each of them could furnish on the average four hundred plates annually, we may estimate the whole photographic work to be finished in about eight years, certainly not in less. To measure off the plates, and to arrange the star catalogue, will require, of course, a much longer time.

In the closing general session, on Monday, April 25, after an exchange of opinion as to name, attributes, duties, etc., it was decided to nominate a permanent committee, consisting of 11 members to be elected, and of the directors of all observatories that participate in the photographical work. The following gentlemen received the highest number of votes: Messrs. Gill, Christie, Vogel, Weiss, Struve, Lœvy, Tacchini, Prosper Henry, Dunér, Janssen, Pickering. The directors of observatories that, on the spot, could make a definite engagement to participate, were Baillaud, of Toulouse; Beuf, of La Plata; Cruls, of Rio de Janeiro; Mouchez, of Paris; Rayet, of Bordeaux; and Trépied, of Algiers.

Thanks were voted to the French Government, to Admiral Mouchez, and to the presiding officer, Mr. Struve, whereupon the Congress adjourned *sine die.*

The greatest courtesy ever characterized the discussions in the sessions. To the foreign members, the hospitable amiability peculiar to the French nation was manifested everywhere, and a visit of the Congress to the astrophysical observatory of Mr. Janssen at Mendon will always be among our most pleasant recollections.

Respectfully submitted.

C. H. F. PETERS.

LITCHFIELD OBSERVATORY OF HAMILTON COLLEGE,
Clinton, N. Y., December, 1887.

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REPORT OF NATIONAL ACADEMY OF SCIENCES.

LETTER

FROM

O. C. MARSH, ACTING PRESIDENT

TRANSMITTING

Report of operations of the National Academy of Sciences during the past year.

APRIL 24, 1879.—Laid on the table and ordered to be printed.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., April 15, 1879.

SIR: In conformity with the requirements of the act of incorporation, approved March 3, 1863, I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year.

Very respectfully, your obedient servant,

O. C. MARSH,
Acting President of the National Academy of Sciences.

The Hon. the SPEAKER
Of the House of Representatives.

REPORT.

The National Academy of Sciences was established by act of Congress, in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

The object of the academy is to advance science, and especially to investigate, examine, experiment, and report on any subject of science or art whenever called upon by any department of the government.

The academy contains, at present, about one hundred members, and these have all been selected for their original researches in science. They represent within their ranks nearly every department of knowledge, and their services, in accordance with the charter of the academy, are always at the disposal of the government, without compensation.

SESSIONS OF THE NATIONAL ACADEMY.

During the past year the academy has held three sessions. The first was the regular annual meeting, held in Washington, April 16th to 19th, 1878; the second was a scientific session, in New York, November 5th to 8th; and the third was a special session, in New York, November 6th, 1878.

STATED SESSION.—HELD IN WASHINGTON CITY, APRIL 16TH TO 19TH, 1878.

The Washington session was held in the Smithsonian Institution, and was presided over by the President, Professor Henry, who gave a short opening address, and another at the close of the meeting. Forty-six members were in attendance, and a number of other scientific men were present by invitation. At this session the following papers were read and discussed:

Titles of papers read at April session.

Agassiz, A.—Formation and structure of Alacrane Reef, on the Yucatan Bank.

Ferrel, Wm.—The theory of water-spouts.

Hall, A.—Report on the orbits of the satellites of Mars.

Pumpelly, R.—The relation of loess and drift to secular disintegration.

Packard, A. S., Jr.—The characteristic invertebrate forms of the central zoo-geographical province of the United States.

Hilgard, J. E.—On an optical ocean salinometer.

Agassiz, A.—Preliminary report on the deep-sea dredgings of the United States Coast Survey steamer Blake, during the past winter, in the Gulf of Mexico and in the Gulf Stream.

Davidson, G.—Abrasions on the northwest coast of America.

Gibbs, W.—On the law of Boyle and Mariotte.

Alvord, B.—Abstract of memoir on the intersection of circles and the intersection of spheres.

Guyot, A.—Biographical memoir of Louis Agassiz; 2d part. Relating to his life and work in America.

Packard, A. S., Jr.—Biographical memoir of Jeffries Wyman.

Newcomb, S.—Plan for measuring the velocity of light.

Norton, W. A.—On the force of effective molecular action.

Peters, C. H. F.—On the value of the results obtained for the solar parallax from the English telescopic observations.

Cope, E. D.—On the vertebrate fauna of the Permian period of the United States.

Draper, H.—Report of progress on the subject of oxygen in the sun.

Pickering, E. C.—Photometric comparison of the components of close double stars.

Hayden, F. V.—On the duplication of geographical names.

Langley, S. P.—Characteristic of some of the lower spectral lines.

Smith, J. L.—A new element of the Cerium group.

Gill, T. N.—On the primary zoo-geographical divisions of the globe and their relations.

Coues, E.—Mr. Wallace and Mr. Allen on geographical distribution, with special reference to the alleged distinctness of the nearctic region.

Riley, C. V.—On the laws governing the movements of the Rocky Mountain locusts.

Le Conte, Joseph.—On the structure and origin of mountains, with special reference to recent objections to the contractional theory.

Pickering, E. C.—Photometric measures of certain faint stars and planets.

Loomis, E.—Contributions to meteorology.

Gilbert, G. K.—Recent displacements in Utah.

Alexander, S.—Supplementary notice on the paper "Whence came the inner satellite of Mars," read at the October session, 1877.

During the session Mr. Thomas A. Edison exhibited to the academy his phonograph and carbon telephone, communicating with the latter through one of the Western Union telegraph wires with the central office of that company in Philadelphia, and members of the academy holding conversation with Mr. Henry Bentley of that city.

REPORTS TO GOVERNMENT.

The president informed the academy that three reports to departments of the government, in response to applications, had been made during the past year, as follows:

1. At the request of the Treasury Department, "On Demerara sugars," by Mr. Genth.
2. At the request of the Navy Department, "On proposed changes in the Nautical Almanac," by Messrs. J. E. Hilgard, Coffin, A. Hall, Schott, Young, Watson, and Peters.
3. At the request of the Treasury Department, "On the use of the polarimeter for determining the values of sugars," by Joseph Henry.

ELECTIONS.

Mr. O. C. Marsh was elected vice-president, and Mr. J. H. C. Coffin home secretary; Mr. Gibbs and Mr. Hilgard having declined re-election.

The present officers of the academy are as follows:

Officers.

	Expiration of term.
———— ————, president	
Marsh, O. C., vice president	April, 1884.
Coffin, J. H. C., home secretary	April, 1884.
Barnard, F. A. P., foreign secretary	April, 1880.
Rogers, Fairman, treasurer	April, 1881.

Council elected for 1878–'79.—Baird, S. F.; Hall, A., Gibbs, W.; Hilgard, J. E.; Meigs, M. C.; Newcomb, S.

The following new members were elected: Walker, Francis A.; Trowbridge, John; Le Conte, John.

TREASURER'S REPORT.

The treasurer presented the following report, which was audited by a committee, and approved:

Dues from members collected during the past year		$370 00
Cash balance from last year		750 38
		1,120 38
Expended for printing, principally for memoirs	$511 15	
Copying and clerk's services	29 00	
		540 15
Cash balance on hand		580 23
Due from members		185 00
Total assets		765 23

In the trust account the income was		2,954 03
Balance from last year		2,329 14
		5,283 17
Expended, accrued interest on U. S. loan purchased, afterward repaid	$229 67	
Appropriations by directors of the Bache fund	1,900 00	
Taxes and repairs on houses in Washington	173 89	
Taxes on Missouri lands and safe-rent	23 00	
		2,326 56
Cash balance		2,956 61

Of which $13.81 is uninvested capital.

During the year $30,350 of U. S. six per cent. loan was called in, and the proceeds invested in $30,050 of U. S. four and a half per cent. bonds.

The other investments remain unchanged, the total securities aggregating $43,000, and producing $2,009.72.

A committee was appointed to verify these securities, which subsequently reported the account correct.

JOSEPH HENRY FUND.

The treasurer of the academy made a statement respecting the "Joseph Henry Fund" of $40,000, contributed by Fairman Rogers, Joseph Patterson, George W. Childs, A. J. Drexel, F. A. Drexel, Charles H. Rogers, J. G. Fell, Isaac Lea, Asa Packer, John Welsh, W. Blanchard, James Lennox, Executors of the estate of John C. Green, Mrs. John C. Green, Robert L. Stuart, Miss C. L. Wolfe, William Libbey, E. N. Dickerson, Cyrus W. Field, Thomas A. Scott, W. W. Corcoran, George P. Wetmore, Thomas H. Powers, J. S. Morgan, J. Pierrepont Morgan, I. V. Williamson, John W. Garrett, Charles S. Coxe, Cyrus H. McCormick, J. E. Caldwell, William Weightman, Alexander Brown, Henry C. Gibson, J. Donald Cameron, Samuel M. Felton, H. H. Houston, and Nat. Thayer, "as an expression of the donors' respect and esteem for Professor Henry's personal virtues, their sense of his life's great devotion to science, with its results of important discoveries, and of his constant labors to increase and diffuse knowledge and promote the welfare of mankind"; which sum of $40,000 they have caused to be invested in certain securities, and to be deposited with and held by the Pennsylvania Company for Insurance of Lives and Granting Annuities in Trust, from time to time to collect the income thereon, and to pay over the same to Professor Joseph Henry during his natural life, and after his death to his wife and daughters, and after the death of the last survivor "to deliver the said fund and the securities in which it shall then be invested to the National Academy of Sciences, to be thenceforward forever held in trust under the name and title of the 'Joseph Henry Fund,' the principal to be forever held intact, and the income to be from time to time applied by the said National Academy of Sciences, in its sole discretion, to assist meritorious investigators, especially in the direction of meritorious research."

A resolution was adopted accepting the said trust, and directing, authorizing, and empowering Fairman Rogers, treasurer of the academy, in its name and upon its behalf, to affix its corporate seal to, and to execute all such deeds, writings, and assurances in law as may be necessary to carry the said trust into effect.

Messrs. Henry, Coffin, J. E. Hilgard, Newcomb, Meigs, and Baird, were appointed a committee to procure from Congress an addition to the act of incorporation of the academy which will enable it to accept and administer trust funds.

On motion of Mr. W. B. Rogers, it was unanimously

Resolved, That the National Academy of Sciences hereby present their grateful acknowledgments to Messrs. Joseph Patterson, Fairman Rogers, George W. Childs, and the other subscribers to the "Joseph Henry Fund," for the generous contributions, by which they have expressed their appreciation of the life-long and disinterested scientific labors of the revered president of the academy, and have provided an important future addition to its means of scientific usefulness.

It was also

Resolved, That a committee be appointed by the president to take into consideration the plan proposed by Mr. Simon Newcomb for measuring the velocity of light and the means of carrying it into effect, and to report to the president and council, who shall have power to act.

The council reported a substitute for the pending amendment to the constitution, to take the place of section 5 of Article IV, which was adopted, after discussion, in committee of the whole, and lies over for final action at the next stated session.

NOMINATIONS.

Fourteen nominations for memberships were made, to be acted on at the April session of 1879.

The academy adjourned on the afternoon of April 19, to meet in the city of New York, on the 5th day of November, for the reading of scientific papers only, according to a resolution adopted by the council.

DEATH OF MEMBERS.

A short time after the adjournment of the April session, the academy was called to mourn the loss of its honored president, Professor Joseph Henry, who died in Washington, May 13, 1878. Of the loss to science and to the world of one who has done so much to increase the sum of human knowledge, and to promote its diffusion among men, it is not my province here to speak. Others more familiar with the life-work of Professor Henry will do justice to this suggestive theme. It is, however, fitting that I should allude, at least, to Professor Henry's great services to the academy as its presiding officer during the last ten years.

After the death of the first president of the academy, Professor Alexander Dallas Bache, in 1867, Professor Henry was elected his successor in January, 1868. From that time until he left the chair at the last annual meeting, in April, 1878, it had been his constant thought to advance the best interests of the academy. How zealously he guarded its good name; how impartially and wisely he guided its deliberations; and how earnestly he strove to maintain for it a high standard in science, every member will bear ample testimony.

The biographical memoir of Professor Henry will be prepared by Professor Simon Newcomb, and presented to the academy at the next annual meeting.

The academy has recently lost by death two other members: Dr. Jared P. Kirtland, who died in Cleveland, Ohio, December 10, 1877, and Professor William M. Gabb, whose death occurred in Philadelphia, Pa., May 30, 1878.

SCIENTIFIC SESSION.—HELD IN NEW YORK, NOVEMBER 5 TO 8, 1878.

A scientific session for the reading of papers only having been called by the council, as announced at the April session, the academy convened at Columbia College, New York City, on November 5, 1878. The vice-president, Mr. O. C. Marsh, presiding.

Thirty-nine members were present, and the following papers were read and discussed.

Titles of papers read at November session, 1878.

Draper, Henry.—On the solar eclipse of July 29, 1878.

Scudder, S. H.—The early types of insects.

Peirce, C. S.—On the acceleration of gravity at initial stations.

Trowbridge, W. P.—The inapplicability of the old theory of turbine water-wheels to the new constructions of Boyden and Francis.

Agassiz, A.—The embryology of the gar-pike.

Agassiz, A.—On arrangement of a zoological marine laboratory at Newport.

Abbott, H. L.—On the value of photography in the study of instantaneous phenomena, illustrated by photographs taken at successive stages of torpedo explosions.

Alexander, S.—On the eleventh axiom of Euclid, with a proposed demonstration of the same.

Abbott, H. L.—A biographical memoir of Prof. Dennis Hart Mahan.

Alvord, B.—A continuation of a paper presented at the April meeting on the "Intersection of circles and the intersection of spheres."

Loomis, E.—Contribution to meteorology; storms of the Atlantic Ocean.

Davidson, G.—On instruments of precision at the Paris Exposition.

Newberry, J. S.—On some remains of new fossil fishes and their relation to living forms.

Rood, O. N.—On the quantitative analysis of white light.

Young, C. A.—On measures of the diameter of Mercury by a new method, made at the transit of May 6, 1878.

Alexander, S.—A recapitulation of some of the author's views on the origin of the forms and present state of many of the clusters of stars and of several of the nebulæ, source of solar heat, and drift of the stars.

Newberry, J. S.—On some mooted points in American geology.

Rood, O. N.—On Hering's theory of color.

Cope, E. D.—On the characters of the theromorphous reptilia and stegocephalous batrachia.

Alexander, S.—Brief notice of the total solar eclipse of January 11, 1880.

Hyatt, A.—Some remarks on an investigation of the laws of heredity, undertaken by the Board of Health of Massachusetts.

Alexander, S.—On certain modifications of the Schehallien experiment, and of the Cavendish experiment.

The scientific session closed November 8th.

SPECIAL SESSION.—HELD IN NEW YORK CITY, NOVEMBER 6, 1878.

A special session of the academy having been called by the council, in accordance with section 1, Article III, of the constitution, to take into consideration the surveys of the Territories, the academy convened at Columbia College, New York City, November 6, 1878, at

11 a. m., the acting president, Mr. O. C. Marsh, presiding. Thirty-five members were present. The special session adjourned at 2.30 p. m.

SURVEYS OF THE TERRITORIES.

In June of last year, an act of Congress was passed (sundry civil bill, approved June 20, 1878), containing the following clause:

> And the National Academy of Sciences is hereby required at their next meeting to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, and documents, and other results of the said surveys.

As this was the first instance in which the advice of the academy had been asked by direct act of Congress, the action to be taken in response demanded most careful consideration.

The act of incorporation and the constitution of the academy provided specifically what should be done in such a case. I was required to appoint a special committee to consider the subject. The report of the committee when completed, could, in accordance with the constitution of the academy (Article, V section 4), be transmitted directly to the government, and afterward to the academy at its next stated session. Inasmuch, however, as the subject to be considered was of great importance, I thought it better to have the report submitted first to the academy before transmission to Congress.

In the appointment of this special committee it was obvious that I could not properly select as members any of those who had taken part in the controversy between the then existing government surveys; which contention, it was said, had resulted in the passage of the law for the proposed reorganization. Again, the subjects to be considered by the committee pertained to mensuration, geology, and natural history, and I therefore selected those who were familiar with these branches of science, namely: Prof. James D. Dana, whose long experience as geologist and naturalist of the Wilkes exploring expedition, and subsequent residence at Washington, while preparing his report, had especially fitted him to advise on government work; Prof. William B. Rogers, the Nestor of American geology, who had had long and varied experience with geological and geographical surveys; Prof. J. S. Newberry, the State geologist of Ohio, who had spent several years in the West on government exploring expeditions under the War Department; Prof. W. P. Trowbridge, a graduate of West Point, who, while a member of the Corps of Engineers, served for several years on the Coast Survey; Prof. Simon Newcomb, whose knowledge of mathematics and astronomy rendered his advice most valuable; and Prof. Alexander Agassiz, whose experience both in mining engineering and biology made him a fit representative of those departments.

As the surveys under the War Department and the Interior Department were the special subjects for investigation, I addressed letters to the Secretary of War and the Secretary of the Interior, informing them that a committee of the academy had been appointed to consider the matter, and requested any information as to their plans or wishes in regard to the scientific surveys under their departments they might think proper to lay before the academy. In reply, the Secretary of War sent a communication from the acting Chief of Engineers of the Army, and the Secretary of the Interior sent reports from the Commissioner of the

General Land Office, from Prof. F. V. Hayden, and from Maj. J. W. Powell, all of which were carefully considered by the committee. From other persons, also, including several officers of the Army, and others specially familiar with the government surveys, information was sought and valuable suggestions received. The committee gave the subject careful and conscientious consideration, and the report received their unanimous approval.*

To bring the report before the academy, a special meeting was called, in New York, November 6th, and in the notice issued to members, the clause of the law referring the matter to the academy was quoted in full, so that every member should understand the subject to be considered. The report was submitted to the academy at this meeting, and after a full discussion of three hours was adopted with only a single dissenting vote.

When the session of Congress began, in December last, I transmitted, in accordance with law, an official copy of the report to the President of the Senate, and one to the Speaker of the House of Representatives. As the law asking the advice of the academy originated in the House, I sent to the Speaker, with the report, the special communications relating to the government surveys received from the Secretary of War and the Secretary of the Interior. The report of the academy was duly received by the Senate and ordered to be printed (45th Cong., 3d sess., Mis. Doc. No. 9). The copy sent to the House of Representatives was likewise received and printed with the accompanying documents (45th Cong., 3d sess., Mis. Doc. No. 5).

On the transmission of the report to Congress, the official action of the academy in this matter was, of course, at an end, as the duty required had been performed. As a matter of history, however, I may add that the Committee on Appropriations in the House, to whom the report was referred, embodied the entire plan of the academy in a bill (H. R. 6140), which was duly reported to Congress. The portion of the academy's plan relating to geological surveys and the appointment of a commission on the public lands became a law (sundry civil bill, approved March 3, 1879). A member of the academy, Mr. Clarence King, has since been appointed by the President, director of the new geological survey of the United States, and has entered upon his duties.

In answering the direct requirement of Congress, in a matter of such great importance, it was clearly the duty of the academy, as well as its own interest, to consider the subject without regard to persons or to parties, and to propose a plan which seemed to promise the best results, not merely for to-day, but for the future, as well. Whether the plan proposed by the academy to Congress was the wisest and best that could have been devised, under all the circumstances, may be left for the impartial historian of the future to decide.

REPORT ON VELOCITY OF LIGHT.

At the meeting of the academy, in Washington, in April last, a resolution was adopted authorizing the appointment of a committee to consider a plan proposed by Professor Newcomb, for determining the distance of the sun by measuring the velocity of light. In accordance with this vote, I appointed as members of the committee, President F. A. P. Barnard, Professors Wolcott Gibbs, Henry Morton, George F. Barker, and E. C. Pickering. Their report was so favorable to the plan proposed, that I sent it to the Secretary of the Navy for transmission to Congress.

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* A copy of this report is given in Appendix D.

An appropriation of five thousand dollars for the required purpose was thus secured, and the work of constructing the necessary apparatus will be commenced as soon as the appropriation is available. The expenditure of the funds is intrusted to the Secretary of the Navy. It is hoped by those who proposed this plan that the experiments will lead to a more accurate determination of the distance of the sun than can be obtained by any other method known to astronomy.

A copy of Professor Newcomb's paper, together with the report of the committee to whom it was referred, is given in Appendix E.

NATIONAL BOARD OF HEALTH.

In the act of Congress establishing a National Board of Health, which became a law in March last, the academy is requested and directed to co-operate with this board, and report to Congress at the next session. A communication has been received from the president of the board, inclosing a certified copy of the act, and requesting the academy to appoint an agency with which the board will confer to carry out the provisions of the law. I have informed the president of the board that the academy would co-operate heartily in the proposed work, but no other definite action has as yet been taken.*

I trust that this brief record of work accomplished by the academy during the past year will be conclusive evidence of the importance to the nation of such an organization; and likewise an assurance that the academy will faithfully discharge the duties imposed upon it by any department of the government.

Respectfully submitted.

O. C. MARSH,

Vice-President and Acting President of the National Academy of Sciences.

SUPPLEMENT.

STATED SESSION, APRIL 15 TO 19, 1879.

The stated annual meeting of the National Academy of Sciences was held in Washington, April 15th to 19th, 1879. The acting president, Mr. O. C. Marsh, presided, and by a vote of the academy was requested to append to his report to Congress the proceedings of this session. Forty members were in attendance. The National Board of Health, and Messrs. C. K. Gilbert, C. V. Riley, A. Graham Bell, and Henry Mitchell were invited to be present and take part in the scientific sessions of the academy.

The acting president made an opening address, stating what had been done by the academy during the past year, and also submitted the annual report to Congress, which was read and adopted.

The following papers were read and discussed at this session:

Titles of papers read.

Peirce, C. S.—Ghosts in the diffraction spectra.

Peirce, C. S.—Comparisons of the meter with wave lengths.

Mitchell, S. Weir.—On the relations of neuralgic pains to storms and the earth's magnetism.

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* For the committee on the part of the academy, see Appendix C.

Draper, Henry.—Confirmations by spectrum photographs of the discovery of oxygen in the sun.

Bell, A. Graham.—On vowel theories considered in the light of recent experiments with the phonograph and phonautograph.

Scudder, S. H.—The palæozoic cockroaches.

Pickering, E. C.—On the eclipses of Jupiter's satellites.

Mayer, Alfred M.—On a new form of heliostat.

Cope, E. D.—On the extinct species of the rhinoceros and allied forms of North America.

Peirce, C. S.—On the errors of pendulum experiments, and on the method of swinging pendulums proposed by Mr. Faye.

Hilgard, E. W.—The loess of the Mississippi, and the Æolian hypothesis.

Le Conte, Joseph.—The extinct volcanoes about Lake Mono and their relation to our glacial drift.

Hilgard, J. E.—Report on the progress of the international bureau of weights and measures.

Gilbert, G. K.—On the stability and instability of drainage lines.

Chandler, Charles F.—On a new polariscopic method for the detection and estimation of dextro-glucose in the presence of cane sugar and inverted sugars.

Abbott, Henry L.—On the ignition of high tension fuses.

Riley, C. V.—On the hybernations and migrations of *Aletia argillacea* (the parent of the cotton-worm).

Agassiz, Alexander.—Report on dredgings in the Caribbean Sea by the Coast Survey steamer Blake, Commander John R. Bartlett, United States Navy.

Pickering, E. C.—On two new forms of micrometers.

Mitchell, Henry.—On the physical hydrography of the Gulf of Maine.

Loomis, Elias.—The winds on Mount Washington compared with the winds near the level of the sea.

Brush, G. J.—On a mineral locality in Fairfield County, Connecticut.

Newberry, J. S.—On the great silver deposits recently discovered in Colorado, Utah, and Nevada.

Newcomb, Simon.—On the recurrence of solar eclipses.

Newton, H. A.—On the influence of Jupiter upon bodies passing near that planet.

Peirce, C. S.—On projections of the sphere which preserve the angles.

Barnard, F. A. P.—Report of the Committee on Weights, Measures, and Coinage.

Hilgard, J. E.—An account of geodetic acts determined by the Coast Survey in relation to the figure of the earth.

BIOGRAPHICAL MEMOIRS.

On the evening of April 17th Mr. Justice Bradley read a biographical memoir of the late Dr. Theodore Strong, and Mr. J. S. Newberry, one of the late Dr. Jared P. Kirtland.

ELECTIONS.

Prof. William B. Rogers was elected president in place of Joseph Henry, deceased, and on the last day of the meeting was present and delivered an address in the general session.

The following members were selected for the council of the ensuing year: Alexander Agassiz, S. F. Baird, Wolcott Gibbs, A. Hall, M. C. Meigs, and S. Newcomb.

The following new members were elected: Cleveland Abbe, J. W. Gibbs, W. G. Farlow, H. C. Wood.

TREASURER'S REPORT.

The treasurer presented the following reports, which were audited by committees and approved:

Dues from members collected during the past year		$480 00
Cash balance from the last year		580 23
		1,060 23
Expended for printing	$108 33	
Expended for stationery	7 30	
		115 63
Cash balance on hand		944 60
Due from members		165 00
Total assets		1,109 60
In the trust account the income was		1,952 27
Balance from last year		2,956 11
		4,908 38
Expended:		
Appropriations by the directors of the Bache fund	$1,325 00	
Taxes and repairs on house in Washington, D. C	459 01	
Safe rent	10 00	
		1,794 01
Cash balance on hand		3,114 37

Of which $13.81 is uninvested capital.

The investments remain unchanged.

The committee appointed to examine the securities belonging to the Bache fund reported the following investments:

United States loan 5 per cent	$1,350 00
United States loan 5 per cent	2,500 00
United States loan 5 per cent	8,100 00
United States loan 4½ per cent	30,050 00
City of Davenport loan 6 per cent	1,000 00
	43,000 00

Also the deed for 360 acres of Missouri lands.

Also the deed for part of lot No. 6, square No. 120, on which house No. 723, Twentieth street, Washington, D. C., is built, with policy of insurance thereon.

Also the deed for the piece of ground part of lot No. 7, square No. 120, purchased by the academy.

Also the agreement (one of four) made with the Pennsylvania Company for Insurance on Lives and Granting Annuities, as to the use and final disposition of the Joseph Henry fund for $40,000.

It was reported by the treasurer that by the death of Henry Wood Bache the Bache fund will be increased by the amount of $4,650, according to the terms of the will of Mrs. A. D. Bache.

It was therefore

Resolved, That Fairman Rogers, treasurer, be authorized to receive from the trustee of Henry Wood Bache, under the will of Mrs. A. D. Bache, all cash and securities payable to the National Academy of Sciences in the settlement of his accounts as trustee, and that he be further authorized to execute all papers required in the transaction.

Messrs. J. L. Le Conte and George F. Barker were appointed a committee to examine and verify the securities of the academy for the next April session.

REPORT ON WEIGHTS AND MEASURES.

Mr. F. A. P. Barnard presented a report from the committee on weights, measures, and coinage. The following resolutions appended to the report were adopted:

Whereas the metric system of weights and measures has been very generally adopted for exclusive use in the expression of quantity among civilized peoples; and whereas the probability of the ultimate universal prevalence of this system is becoming daily more and more decided; and whereas these considerations suggest the advisability of making preparation for the possible introduction of this system sooner or later into this country also: Therefore,

Resolved, That, in the opinion of this academy, it is desirable, with a view to such preparation, that provision should be made by State legislation for giving instruction in the principles of the metric system in all the elementary schools in the country; and for making a knowledge of the system a requisite for admission into educational institutions of higher grade; also

That laws should be enacted by Congress requiring the use in the domestic mail service of a metric unit of postal weight identical with that already employed in the foreign; providing for the assessment of duties upon merchandise imported under metric invoices to be made in accordance with a tariff adapted to metric denominations of weight and measure; and expressing the weights of all coins issued from the mints of the United States in grams and milligrams, and no longer in grains and fractions of grains, as at present.

Resolved further, That copies of the foregoing preamble and resolution, duly authenticated, be communicated to the President of the United States, the President of the Senate, the Speaker of the House of Representatives, the chairman on the Committee on Finance of the Senate, the chairman of the Committee on the House on Weights, Measures, and Coinage, and the governors of the several States and Territories.

The resolutions were approved by Messrs. F. A. P. Barnard, H. A. Newton, S. Newcomb, J. E. Hilgard, W. P. Trowbridge, Henry Draper, and C. S. Peirce.

Mr. M. C. Meigs, also a member of the committee, dissented to the report and resolutions and presented a minority report.

AMENDMENTS TO CONSTITUTION AND RULES.

The pending amendment to section 5, Article IV of the constitution, was not adopted.

A substitute for section 5, Article IV, and an amendment to section 2, Article V of the constitution, were recommended by the council, considered in committee of the whole, and adopted, to be voted on at the next stated session.

Rule VII was amended so as to read:

> The death of members shall be announced by the president on the last day of any session, when a member shall be selected by the president to furnish a biographical notice of the deceased at the next session. If such notice be not then furnished, another member may be selected by the president in place of the first, and so on until the duty is performed.

The following rule was also adopted:

On the first day of each stated session, immediately after calling the roll of members, a recording secretary shall be elected by a plurality of votes of members present to assist the home secretary in keeping the records of the session.

The home secretary was instructed to address a circular to all members asking them to state the special line of their researches and investigations for the use of the president and council.

Fifteen nominations were made for membership, and one for foreign associate, to be acted upon at the April session of 1880.

The academy adjourned on the evening of April 18th.

O. C. MARSH,
Vice-President.

WASHINGTON, D. C., *April* 18, 1879.

APPENDIX A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, U. S. A., Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, U. S. N., Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, U. S. N., Massachusetts; George Englemann, Saint Louis, Mo.; J. F. Fraser, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, U. S. N., Kentucky; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, U. S. A., Pennsylvania; J. L. Le Conte, U. S. A., Pennsylvania; J. Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, U. S. N., Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, jr., Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, U. S. A., Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate by the name of the National Academy of Sciences.

SEC. 2. *And be it further enacted,* That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members; the division into classes, and all other matters needful or useful in such institutions, and to report the same to Congress.

SEC. 3. *And be it further enacted,* That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the academy shall, whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the academy shall receive no compensation whatever for any services to the Government of the United States.

Approved March 3, 1863.

AN ACT to amend the act to incorporate the National Academy of Sciences.

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, That the act to incorporate the National Academy of Sciences, approved March 3d, eighteen hundred and sixty-three, be, and the same is hereby, so amended as to remove the limitation of the number of ordinary members of said academy as provided in said act.

Approved July 14, 1870.

APPENDIX B.

CONSTITUTION AND RULES OF THE NATIONAL ACADEMY OF SCIENCES.

[As amended and adopted April 17, 1872, and further amended April 20, 1875.]

PREAMBLE.

Empowered by the act of incorporation enacted by Congress, and approved by the President of the United States on the 3d day of March, A. D. 1863, and in conformity with the amendment to said act approved July 14, 1870, the National Academy of Sciences adopt the following amended constitution and rules:

ARTICLE I.—*Of members.*

SECTION 1. The academy shall consist of members, honorary members, and foreign associates.

SEC. 2. Members who, from age or inability to attend the sessions of the academy, wish to resign the duties of active membership may, at their own request, be transferred to the roll of honorary members by a vote of the academy.

SEC. 3. The academy may elect fifty foreign associates.

SEC. 4. Honorary members and foreign associates shall have the privilege of attending the meetings, and of reading and communicating papers to the academy, but shall take no part in its business, shall not be subject to its assessments, and shall be entitled to a copy of the publications of the academy.

ARTICLE II.—*Of the officers.*

SECTION 1. The officers of the academy shall be a president, a vice-president, a foreign secretary, a home secretary, and a treasurer, all of whom shall be elected for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy the election for six years shall be held in the same manner at the session when such vacancy occurs, or at the next stated session thereafter, as the academy may direct.

SEC. 2. The officers of the academy, together with six members to be elected by the academy at the first stated session in each year, shall constitute a council for the transaction of such business as may be assigned to them by the constitution or the academy.

SEC. 3. The president of the academy or, in case of his absence or inability to act, the vice-president shall preside at the meetings of the academy and of the council; shall name all committees, except such as are otherwise provided for; shall refer investigations required by the Government of the United States to members specially conversant with the subjects, and report thereon to the academy at its session next ensuing; and, with the council, shall direct the general business of the academy.

It shall be competent for the president, in special cases, to call in the aid, upon committees, of experts, or men of special attainments, not members of the academy.

SEC. 4. The foreign and home secretaries shall conduct the correspondence proper to their respective departments, advising with the president and council in cases of doubt, and reporting their action to the academy at one of the stated sessions in each year. It shall be the duty of the home secretary to give notice to the members of the place and time of all meetings, of all nominations for memberships, and of all proposed amendments to the constitution.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the home secretary.

SEC. 5. The treasurer shall attend to all receipts and disbursements of the academy, giving such bond and furnishing such vouchers as the council may require. He shall collect all dues from members, keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the April session. He shall be the custodian of the corporate seal of the academy.

ARTICLE III.—*Of the meetings.*

SECTION 1. The academy shall hold one stated session in each year, in the city of Washington, on the third Tuesday in April, and another may be held at such time and place as the council shall determine.

Special sessions of the academy may be called by order of eight members of the council, at such place and time as may be designated in the call.

Scientific sessions of the academy may be held at times and places to be designated by a majority of the council.

SEC. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SEC. 3. Scientific meetings of the academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business closed.

SEC. 4. The stated meetings of the council shall be held during the stated or special sessions of the academy. Special meetings may be convened at the call of the president and two members of the council, or of four members of the council.

SEC. 5. No member who has not paid his dues shall take part in the business of the academy.

ARTICLE IV.—*Of elections and resignations.*

SECTION 1. All elections shall be by ballot, and each election shall be held separately, unless otherwise ordered by this constitution.

SEC. 2. The time for holding an election for officers shall be fixed by the academy at least one day before the election is held.

SEC. 3. The six additional members of the council shall be elected on any day after the first of the first stated session in each year by each voter inscribing six names on his ballot, and those six who have received more votes than any other shall be declared elected. If two or more names have received the lowest number of votes that would elect, additional balloting shall be had for as many members as remain each time to be elected until the number is full.

The term of the members so elected shall commence at the close of the session at which they are elected, and continue until the close of the first stated session in the next year.

SEC. 4. Nominations of members and foreign associates may be made in writing, signed by any five members of the academy at any stated session, to be voted on at the next stated session, and each nomination shall at the time of election be accompanied by a written list of the original works of the nominee.

SEC. 5. Elections for members shall be held in the following manner: One name shall be selected by ballot from the nominations presented. The name receiving the highest number of votes (provided that they are at least one-third of those cast) shall thereupon be voted on by ballot for membership, and if two-thirds of the votes cast, including blank votes, are in the affirmative, the person voted for shall be declared elected a member of the academy. Any name failing to receive two-thirds of the votes cast shall not be voted for a second time on the same day; and unless receiving one-third of the votes cast shall not be again put in nomination at that session of the academy.

Absent members may send their votes to the secretary, which shall be counted in the ballot for election, but not in that for preference.

Before each election a discussion of the merits of the nominees will be in order.

Elections of members shall only be held at stated sessions, and after that of April, 1872, not more than five members shall be elected at any one session.

SEC. 6. Every member elect shall accept his membership, personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SEC. 7. Nominations and elections of foreign associates shall be conducted in the same manner as those of members.

SEC. 8. A diploma, with the corporate seal of the academy and the signature of the officers, shall be sent by the appropriate secretary to each member on his acceptance of his membership, and to foreign associates on their election.

SEC. 9. Resignations shall be addressed to the president and acted on by the academy.

ARTICLE V.—*Of scientific communications, publications, and reports.*

SECTION 1. Communications on scientific subjects shall be read at scientific meetings of the academy, and papers by any member may be read by the author or by any other member, notice of the same having been previously given to the secretary.

SEC. 2. Any member of the academy may read a paper from a person who is not a member, and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

Persons who are not members may read papers upon invitation of the academy.

SEC. 3. The academy may provide for the publication, under the direction of the council, of proceedings, memoirs, and reports.

SEC. 4. Propositions for investigations or reports by the academy shall be submitted to the council for approval, except those requested by the Government of the United States, which shall be acted on by the president, who will, in such cases, report their results to the government as soon as obtained, and to the academy at its next following stated session.

SEC. 5. The advice of the academy shall be, at all times, at the disposition of the government upon any matter of science or art within its scope.

SEC. 6. An annual report to be presented to Congress shall be prepared by the president, and before its presentation submitted by him, first to the council, and afterwards to the academy at one of the stated sessions.

SEC. 7. Medals and prizes may be established, and the means of bestowing them accepted by the academy, upon the recommendation of the council, by whom all the necessary arrangements for their establishment and award shall be made.

Bequests and trusts having for their object the advancement of science may also be accepted and administered by the academy.

ARTICLE VI.—*Of the property of the academy.*

SECTION 1. All investments shall be made by the treasurer, in the corporate name of the academy, in stocks of the United States.

SEC. 2. No contract shall be binding upon the academy which has not been first approved by the council.

SEC. 3. The assessments required for the support of the academy shall be fixed by the academy on the recommendation of the council.

ARTICLE VII.—*Of additions and amendments.*

Additions and amendments to the constitution shall be made only at a stated session of the academy. Notice of a proposition for such a change must be given at a stated session, and shall be referred to the council, which may amend the proposition, and shall report thereon to the academy at the same session. Its report shall be considered by the academy in committee of the whole for amendment.

The proposition as amended, if adopted in committee of the whole, shall be voted on at the next stated session, and if it receive two-thirds of the votes cast, it shall be declared adopted.

Absent members may send their votes on pending changes in the constitution to the home secretary in writing, and such votes shall be counted as if the member were present.

RULES.

I. In the absence of any officer a member shall be chosen to perform his duties temporarily, by a plurality of *viva voce* votes, upon open nomination.

II. The accounts of the treasurer shall be referred to an auditing committee of three members, to be appointed by the president at the meeting at which the accounts are presented; which committee shall report before the close of that session, and shall then be discharged.

The bonds, securities, and other property owned or held in trust by the academy shall be inspected and verified by a committee to be annually appointed by the president. The report of this committee shall be presented to the academy at its first stated session in each year, and referred with the accounts to the auditing committee.

III. A committee of arrangements, consisting of five members, shall be appointed by the president for each stated session of the academy. This committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings, to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, &c.; and to arrange the order of reading, and in general to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be as follows:

1. Chair taken by the president, or, in his absence, by the vice-president.
2. Roll of members called by home secretary.
3. Minutes of the preceding meeting read and approved.
4. Stated business.
5. Reports of president, secretaries, treasurer, and committees.
6. Business from council.
7. Other business.
8. Rough minutes read for correction.

V. The rules of order of the academy shall be those of the Senate of the United States, unless suspended by unanimous consent.

VI. Unless otherwise ordered by the academy, the scientific meeting shall be convened at noon.

VII. The death of members shall be announced by the president on the last day of any session, when a member shall be selected by the president to furnish a biographical notice of the deceased at the next session. If such notice be not then furnished, another member may be selected by the president in place of the first, and so on until the duty is performed.

VIII. All discussions as to the claims and qualifications of nominees at meetings of the academy will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the academy at the time of the discussion.

IX. The secretaries will receive memoirs at any time and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the academy.

X. Memoirs shall date in the records of the academy from the date of their presentation to the academy, and the order of their presentation shall be that in which they were registered, unless changed by consent of the author.

XI. Papers from persons not members, read before the academy and intended for publication, shall be referred, at the meeting at which they are read, to a committee of members competent to judge whether the paper is worthy of publication. Such committee shall report to the academy as early as practicable, and not later than the next stated session.

XII. An annual of the academy shall be prepared and published by the secretaries.

XIII. The printing of the academy shall be under the charge of the secretaries and the treasurer, as a committee of publication, who shall report in relation thereto at each April session of the academy.

XIV. The annual report of the academy may be accompanied by a memorial to Congress in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XV. The proper secretary shall acknowledge all donations made to the academy, and shall report them at the next stated session.

XVI. The books, apparatus, archives, and other collections of the academy shall be deposited in some safe place in the city of Washington. A list of the articles so deposited shall be kept by the home secretary, who is authorized to employ a clerk to take charge of them.

XVII. A stamp corresponding to the corporate seal of the academy shall be kept by the secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels or other proper marks, of similar device, shall be placed upon objects not admitting of the stamp.

XVIII. On the first day of each stated session, immediately after calling the roll of members, a recording secretary shall be elected by a plurality of members present, to assist the home secretary in keeping the records of the session.

XIX. It shall be the duty of the committee of arrangements to fix the length of time to be devoted to reading of all papers submitted, and to limit the time to be occupied in their discussion.

Only members and persons attending the meetings by invitation of the council shall be entitled to take part in the discussions.

XX. Any rule of the academy may be amended, suspended, or repealed on the written motion of any two members, signed by them and presented at a stated session of the academy, provided the same shall be approved by a majority of the members present.

APPENDIX C.

ORGANIZATION OF THE NATIONAL ACADEMY OF SCIENCES, 1879–80.

	Expiration of term.
Rogers, William B., president	April, 1885.
Marsh, O. C., vice-president	April, 1884.
Barnard, F. A. P., foreign secretary	April, 1880.
Coffin, J. H. C., home secretary	April, 1884.
Rogers, Fairman, treasurer	April, 1881.

Council, April, 1879–'80.—Agassiz, A.; Baird, S. F.; Gibbs, W.; Hall, A.; Meigs, M. C.; Newcomb, S.

COMMITTEES OF THE ACADEMY.

Committee on weights, measures, and coinage.—Barnard, F. A. P.; Draper, Henry; Gibbs, Wolcott; Hilgard, J. S.; Newcomb, S.; Meigs, M. C.; Newton, H. A.; Peirce, C. S.; Trowbridge, W. P.

Committee on ways and means to provide a fund for the academy.—Rogers, Fairman; Rogers, W. B.; Chandler, C. F.; Marsh, O. C.; Agassiz, Alexander; Smith, J. Lawrence.

Committee to verify the securities of the trust-fund of the academy.—Le Conte, J. L.; Barker, George F.

Committee to co-operate with the National Board of Health.—S. Weir Mitchell, Philadelphia, Pa.; George Engelmann, Saint Louis, Mo.; J. Lawrence Smith, Louisville; J. J. Woodward, Washington, D. C.; F. A. Walker, Washington, D. C.; George F. Barker Philadelphia, Pa.; Charles F. Chandler, New York City; Henry Draper, New York City; Wolcott Gibbs, Cambridge, Mass.

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES.

Abbe, Cleveland, Washington, D. C.
Abbott, Henry L., U. S. A., Whitestone, Long Island, N. Y.
Allen, J. Asaph, Cambridge, Mass.
Agassiz, Alexander, Cambridge, Mass.
Alexander, Stephen, Princeton, N. J.
Baird, Spencer F., Washington, D. C.
Barker, George F., Philadelphia, Pa.
Barnard, Frederick A. P., New York City.
Barnard, J. G., U. S. A., New York City.
Bartlett, William H. C., Yonkers, N. Y.
Brown-Sequard, Charles E., 18 East Twenty-ninth street, New York.
Brush, George J., New Haven, Conn.
Chandler, Charles F., New York City.
Coffin, John H. C., U. S. N., Washington, D. C.
Cooke, Josiah P., jr., Cambridge, Mass.
Cope, Edward D., Philadelphia, Pa.
Coues, Elliott, U. S. A., Washington, D. C.
Crafts, James M., 44 Beacon street, Boston, Mass.
Dalton, John C., 41 West Forty-eighth street, New York City.
Dana, James D., New Haven, Conn.
Davidson, George, San Francisco, Cal.
Draper, Henry, New York City.
Draper, John W., Hastings on Hudson, N. Y.
Eads, James B., Saint Louis, Mo.
Farlow, W. G., Cambridge, Mass.
Ferrel, William, Washington, D. C.
Genth, Frederick A., Philadelphia, Pa.
Gibbs, Josiah Willard, New Haven, Conn.
Gibbs, Wolcott, Cambridge, Mass.
Gill, Theodore, Washington, D. C.
Gould, Benjamin Apthorp, Cordoba, Argentine Republic, South America.
Guyot, Arnold, Princeton, N. J.
Haldeman, S. S., Chickies, Pa.
Hall, Asaph, U. S. N., Washington, D. C.
Hall, James, Albany, N. Y.
Hayden, F. V., Washington, D. C.
Hilgard, Eugene W., Oakland, Cal.
Hilgard, Julius E., Washington, D. C.
Hill, George W., Washington, D. C.
Humphreys, A. A., U. S. A., Washington, D. C.
Hunt, T. Sterry, Saint James Hotel, Boston, Mass.
Hyatt, Alpheus, Boston, Mass.
Johnson, Samuel W., New Haven, Conn.
King, Clarence, Washington, D. C.
Lane, J. Homer, Washington, D. C.
Langley, Samuel P., Allegheny Observatory, Pa.
Lesley, J. Peter, 1008 Clinton street, Philadelphia, Pa.
Loomis, Elias, New Haven, Conn.
Le Conte, John, Berkley, Cal.
Le Conte, John L., 1625 Spruce street, Philadelphia, Pa.
Le Conte, Joseph, Oakland, Cal.
Lesquereux, Leo, Columbus, Ohio.
Lovering, Joseph, Cambridge, Mass.
Lyman, Theodore, Cambridge, Mass.
Marsh, George P., Rome, Italy.
Marsh, O. C., New Haven, Conn.
Mayer, Alfred M., Hoboken, N. J.

Meigs, M. C., U. S. A., Washington, D. C.
Mitchell, S. Weir, 1332 Walnut street, Philadelphia, Pa.
Morgan, Lewis H., Rochester, N. Y.
Morse, Edward S., Salem, Mass.
Morton, Henry, Hoboken, N. J.
Newberry, J. S., New York City.
Newcomb, Simon, U. S. N., Washington, D. C.
Newton, H. A., New Haven, Conn.
Newton, John, U. S. A.
Norton, William A., New Haven, Conn.
Oliver, James E., Ithaca, N. Y.
Packard, A. S., jr., Providence, R. I.
Peirce, Charles S., U. S. C. S., Washington, D. C.
Peters, C. H. F., Clinton, N. Y.
Pickering, Edward C., Cambridge, Mass.
Pourtales, L. F., Cambridge, Mass.
Pumpelly, Raphael, Owego, N. Y.
Rodgers, John, U. S. N., Washington, D. C.
Rogers, Fairman, 202 West Rittenhouse square, Philadelphia, Pa.
Rogers, Robert E., 1104 Walnut street, Philadelphia, Pa.
Rogers, William B., Boston, Mass.
Rood, Ogden N., New York City.
Rutherfurd, Lewis M., 175 Second avenue, New York City.
Schott, Charles A., Washington, D. C.
Scudder, Samuel H., Cambridge, Mass.
Sellers, William, Philadelphia, Pa.
Silliman, Benjamin, New Haven, Conn.
Smith, J. Lawrence, Louisville, Ky.
Trowbridge, John, Cambridge, Mass.
Trowbridge, Wiliam P., New York City.
Trumbull, J. H., Hartford, Conn.
Tuckerman, Edward, Amherst, Mass.
Verrill, A. E., New Haven, Conn.
Walker, Francis A., New Haven, Conn.
Warren, G. K., U. S. A., Newport, R. I.
Watson, James C., Ann Arbor, Mich.
Whitney, William D., New Haven, Conn.
Wood, Horatio C., Philadelphia, Pa.
Woodward, J. J., U. S. A., Washington, D. C.
Worthen, A. H., Springfield, Ill.
Young, C. A., Princeton, N. J.

HONORARY MEMBERS.

Engelmann, George, Saint Louis, Mo.
Gray, Asa, Cambridge, Mass.
Leidy, Joseph, Philadelphia, Pa.
Longstreth, Miers F., Derby, Pa.

APPENDIX D.

REPORT ON SURVEYS OF THE TERRITORIES.

At a meeting of the National Academy of Sciences, held in New York on November 6, 1878, the acting president submitted the report of the special committee to consider the scientific surveys of the Territories of the United States.

REPORT.

The committee of the National Academy of Sciences, to whom has been referred the consideration of the following requirement of law contained in the act making appropriations for sundry civil expenses of the government for the fiscal year ending June 30, 1879, and for other purposes, approved June 20, 1878, namely:

"And the National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the

Land Office, and to report to Congress as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, and documents, and other results of said surveys,"
submit the following report:

The committee consider that the field of inquiry proposed to the academy is intended to embrace only such surveys as pertain to the public domain. They have not included in their plan of organization surveys and investigations, however scientific in method and character, which apply solely to engineering works, such as the improvements of rivers, harbors, lakes, &c.; the irrigation and drainage of public lands, reclamation of tidal lands and protection of alluvial regions from floods. Such surveys and investigations, being inseparably connected with engineering problems, should, in the judgment of the committee, be conducted by the Engineer Corps of the Army. Nor do the committee recommend any change in the organization of the survey of the great lakes, as this is now nearly completed.

The works which seem to fall especially within the limits of the meaning of the law are: The geographical surveys west of the one hundredth meridian, under the War Department; the United States geographical and geological surveys of the Territories and of the Rocky Mountain region, under the Interior Department; and the system of land surveys under the supervision of the Land Office. Besides these, although not enumerated in the law, one of the most important works now in progress in the interior, under act of Congress, is the geodetic work of the Coast and Geodetic survey. Parties of this organization are now conducting a systematic triangulation at several points in the interior, and any general system, such as is contemplated in the above law, cannot be wisely devised without taking into account the object and organization of this survey. The objects of these various surveys are: 1. An accurate geodetic survey; 2. A general geographical and topographical reconnaissance; 3. Land-parcelling surveys, on which the government can part title to portions of the public domain; 4. The economic classification and valuation of the public domain. To these should be added the gradual completion of a general accurate topographical map of the whole territory of the United States, which shall serve as a basis for all the scientific and practical needs of the government and the people. All this may be included under two distinct and separate heads: 1. Surveys of mensuration; 2. Surveys of geology and economic resources of the soil.

We will first consider the present operations of the surveys of mensuration. Such surveys are now in progress under five different independent organizations: That of the Coast and Geodetic Survey; of the geographical surveys west of the one hundredth meridian, under the War Department; of the topographical work of the two surveys under the Interior Department; and of the land-survey under the Land Office. The final object of all these works of mensuration is the accurate determination of position and the laying down of lines and points by measurement. There is at present no co-ordination between these five surveys. Their original determination of position are independent; their systems of surveys discordant; their results show many contradictions and involve unnecessary expenditure. The geographical reconnaissances carried on under the War and Interior Departments are of little value for the parcelling of land, while the land surveys are of correspondingly slight topographical and geographical value. The operations of the Coast and Geodetic Survey in the interior do not at present include topography and land-parcelling. To attain the desirable accuracy and economy it is absolutely essential that there should be only one geodetic system, one topographical system, and one land-parcelling system, all conducted under the same head. It is evident that both topographical and land-parcelling surveys, to be properly co-ordinated and sufficiently exact, must be based upon a single rigid geodetic foundation. All these three divisions are departments of measuring; all are based upon accurate determinations of position; and, to be effective and economically carried out, should be united into one comprehensive system.

After a careful consideration of the facilities at the disposal of the several existing organizations engaged in this work, the committee believe that the Coast and Geodetic Survey is practically best prepared to execute the entire mensuration system required. Within the public domain the dominant interest of the United States is centered in the public lands which remain to be surveyed and sold.

The administration of these lands, consisting of 1,101,107,183 acres, is necessarily within the Department of the Interior, while the Coast and Geodetic Survey, having been originally inaugurated to meet the wants of commerce, has been hitherto under the Treasury Department. In view of the paramount importance of the public lands, the committee recommend that the Coast and Geodetic Survey be transferred from the Treasury Department to the Department of the Interior, retaining its original field of operations, and assuming, also, the entire mensuration of the public domain; and that, so modified and extended, it hereafter be known as the United States Coast and Interior Survey. This organization would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnaissance, and land-parcelling surveys.

The superintendent of the Coast and Interior Survey should be appointed by the President, and should report directly to the Secretary of the Interior.

The best interests of the public domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources, and products. The domain embraces a vast mineral wealth in its soils, metals, salines, stones, clays, &c. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The committee, therefore, recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the public domain; such survey to be placed under a director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior.

It should be specially provided that the director and members of the Geological Survey, charged as they are with the investigations of the natural resources of the public domain, shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations.

Officers of the Army and Navy, when not otherwise employed, might be detailed by the Secretary of War or the Secretary of the Navy to take part in the operations of either survey.

With the inauguration of the two surveys above defined, the committee recommend a discontinuance (1) of the present geographical and geological surveys west of the one hundredth meridian, under the War Department, except surveys necessary for military purposes and local internal improvements; (2) of the geographical and geological surveys now in progress under the Department of the Interior; and (3) the present land surveys under the Land Office.

The effect of the above changes will be to maintain within the Interior Department three distinct organizations: (1) the Coast and Interior Survey, whose function will embrace all questions of position and mensuration; (2) the United States Geological Survey, whose function will be the determination of all questions relating to the geological structure and natural resources of the public domain; (3) the Land Office, controlling the disposition and sale of the public lands, including all questions of title and record. With this division should be secured a perfect co-ordination and co-operation between the three branches. The Land Office should call upon the Coast and Interior Survey for all surveys and measurements required for the sale and disposition of land. The Land Office should also call upon the United States Geological Survey for all information as to the value and classification of lands. The results of all the mensuration surveys, as soon as completed, should be immediately available for the Land Office, and for the Geological Survey, and for other branches of the government as required. The Geological Survey should be authorized to execute local topographical surveys for special purposes; such, for instance, as the subterraneous surveys of mining districts and metallic deposits, &c.

Each of the three organizations, thus defined, should make an annual report of its operations to the Secretary of the Interior. The publications of the Land Office should embrace reports of its business operations relating to the disposition and sale of land, together with the necessary maps. The publications of the Coast and Interior Survey, besides the annual report of operations, should consist of its geodetic results, geographical, topographical and cadastral maps, coast charts and such discussion and treatises connected therewith as the superintendent shall deem of value. The publications of the Geological Survey should consist of an annual report of operations, geological and economic maps illustrating the resources and classification of the land, reports upon general and economical geology in all its branches, with the necessarily connected paleontology.

All collections made by the Coast and Interior, and the Geological Surveys, when no longer needed for the investigations in progress, should be transferred to the National Museum.

The committee recommend, that upon the organization of the United States Coast and Interior Survey and the United States Geological Survey, a commission be formed, to consist of the Commissioner of the Land Office, Superintendent of the Coast and Interior Survey, Director of the United States Geological Survey, and Chief of Engineers of the Army, and three other persons to be appointed by the President, who shall take into consideration the codification of the present laws relating to the survey and disposition of the public domain; and who shall report to Congress, within one year, a standard of classification and valuation of the public land, together with a system of land-parcelling survey. The necessity of this commission is evident from the fact that by far the larger part of the public domain lies in the region where, from geological and climatic causes, the lands are for the most part not valuable for field-culture, and where the system of homestead pre-emption and sale in accordance with existing laws is both impracticable and undesirable.

In regard to publications of the two surveys above defined, the committee recommend, that besides the number of copies of each report which Congress may order for its own distribution, three thousand copies be published for scientific exchanges by the heads of these surveys, and for sale at the price of publication; that all literary and cartographic material received by the heads of these surveys in exchange be the property of the United States, and form a part of the libraries of the two organizations; that the money resulting from the sale of these publications be covered into the Treasury. The committee recommend that the annual reports of operations of the two surveys accompany the report of the Secretary of the Interior; that the special memoirs and reports of both surveys be issued in uniform quarto series; that the style and scale of the cartographic publications be determined by the head of each organization, so as to express the scientific results in the most effective and economical manner.

All of which is respectfully submitted.

O. C. MARSH,
Vice-President and Acting President.
JAMES D. DANA,
WILLIAM B. ROGERS,
J. S. NEWBERRY,
W. P. TROWBRIDGE,
SIMON NEWCOMB,
ALEX. AGASSIZ,
Members of the Committee.

NEW YORK, *November* 6, 1878.

At the meeting of the National Academy of Sciences, held in New York November 6, 1878, the above report was adopted.

O. C. MARSH,
Acting President.

J. H. C. COFFIN,
Home Secretary.

APPENDIX E.

ON A PROPOSED MODIFICATION OF FOUCAULT'S METHOD OF MEASURING THE VELOCITY OF LIGHT.

By SIMON NEWCOMB.

[Communicated to the National Academy of Sciences, April —, 1878.]

The measurement of the velocity of light has justly been regarded as among the most important as well as most difficult of optical experiments. The difficulty arises from the extreme velocity. An idea of it may be formed by reflecting that light would pass around the earth eight times in a single second, and would pass between the most distant stations on the earth's surface, visible to each other, in a fraction of a thousandth part of a second. Its importance arises partly from the knowledge which we may hope thence to attain respecting the qualities of the luminiferous ether and the relation between light, electricity and other visible forces, and partly from the fact, now generally recognized, that a successful and accurate measure of this velocity would enable us to determine the distance of the sun with more accuracy than by any other method. The time required for light to come from the sun to the earth may be considered as known within the fraction of a second by the phenomena of aberration. It, therefore, only remains to determine its velocity in miles per second to obtain the distance of the sun in miles. It is a curious fact that, so far as known, no attempt to determine the velocity of light has been made, except by French physicists. Two distinct methods have been applied by them, which are associated with the names of their respective inventors, Fizeau and Foucault. The essential feature of the latter method is a revolving mirror from which a beam of light is reflected to a fixed concave mirror, thence reflected back to the revolving mirror, and so returned to its original source. The space through which the light passed in order to have the time of passage measured was only a few yards. It would have been impossible to see the image of Foucault's reticule with his fixed reflector at any considerable distance.

In the method of Fizeau the main feature is a revolving tooth-wheel. A ray of light is sent between the teeth of the wheel to the distant reflector, and on its return is cut off by the intervention of a tooth, because the wheel moves during the interval required by the light to go and come. As compared with the former method this has the advantage that the distant reflector can be placed many miles away, so that the time to be measured is greatly increased, but it has the disadvantage that it is impossible to fix the precise velocity of revolution of the toothed wheel at which the return light is cut off. As the velocity varies, the disappearance of the light is not sudden, but gradual: doubt must therefore always remain as to the exact velocity when it disappears. On the other hand, in the method of Foucault, the velocity depends upon an angular measure with the micrometer, which can be made with great precision, if we can only obtain a considerable angular deviation.

The result of these uncertainties is that the measures made by the two French physicists differ by nearly one per cent. of their whole amount. Using the velocity recently found by Cornu, by Fizeau's method, the solar parallax would be 8″.794, while Foucault's measures give 8.860. These are about the admissible limits of the solar parallax as determined by other methods, so that no decisive result can be obtained until we know which determination is correct. It is now proposed to combine the advantages of both methods by using a revolving mirror, and also placing the fixed reflector at a considerable distance, probably between one and three miles. The lines of a reticule will of course then be invisible, and any source of light will be greatly enfeebled. The difficulty thus arising may be avoided by using, not a reticule, but an image of a slit illuminated either by an electric light, or by the direct light of the sun.

In the plan which I have myself worked out, I propose to use a larger mirror than that employed by Foucault. Of course a high velocity will not then be attainable, but, on the other hand, a much more accurate and certain optical measurement may be possible. The lower velocity of the mirror may be more than compensated by the great distance at which it will be possible to place the fixed reflector. By this modification it will not be possible to see the returning image in the same telescope through which the ray is sent. I propose, therefore, to use two telescopes, one to send the ray out, and another to receive it on its return. The size of the mirror will then have to be doubled. The most advantageous size will probably be three inches by six inches, the axis of revolution being longitudinal. The lower half of the mirror will be used to send the ray out, while on its return it will be received on the upper half.

Recent trials of a still different and more simple apparatus have been made at the Naval Academy by Ensign Albert A. Michelson, U. S. N. His apparatus is more like that of Foucault than that which I propose. The main improvement which he has made is the obviously essential one of placing the fixed mirror at a considerable distance, and using direct sunlight instead of the image of a reticule. In examining Mr. Michelson's apparatus I have been surprised at the great ease with which all the difficulties I had anticipated may be overcome. To prevent any misapprehension, I will say that his apparatus has been entirely of his own devising.

What I now hope is that the academy will give its sanction to some method of procuring the funds necessary to carry out these experiments. Several of our physicists have made efforts in this direction, the most recent, so far as I am aware, being our colleague, Professor Barker. They have thus far been unsuccessful, and the academy may consider the question of sufficient national importance to ask the government to bear the expense.

REPORT ON MEASURING THE VELOCITY OF LIGHT.

The select committee to whom it was referred to consider "The plan proposed by Professor Newcomb for measuring the velocity of light, and the means of carrying it into effect," with instructions to report on the subject to the president and council, have attended to the duty assigned them, and beg leave to report as follows:

The object which Professor Newcomb hopes to accomplish by his proposed experimental investigations is one of great scientific importance. To determine with accuracy the velocity with which light is propagated through space is not only to settle a question of much interest in physical optics, but also to contribute valuable aid toward the solution of important and difficult questions in astronomy.

The approximate values heretofore obtained for the velocity of light have been reached by methods belonging to two classes characteristically different—the first astronomical, the second mechanical. It is to astronomy, indeed, that we owe our knowledge of the fact that light is not propagated instantaneously to any distance. The discussion of the eclipses of the satellites of Jupiter by Roemer, about two hundred years ago, brought clearly out the fact that the times of observed occurrence of the phenomena are affected by the distance of the planet from the earth, and that the discrepancies between the observed and calculated times are proportionate to the variations of this distance. The dimensions of the earth's orbit furnish, therefore, a means of measuring the rate at which light travels through space. This means might have sufficed for the purpose, had the dimensions of the orbit been themselves exactly known.

Whatever knowledge we possess, however, of these dimensions depends upon the degree of accuracy with which the sun's horizontal parallax has been ascertained; and this, while it is the most important of the constants of astronomy, is also the most difficult of all to be determined. No other has occupied so many years of the time of astronomers, or has been the subject of so protracted and unwearied labors on the part of observers and computers, as this. The celestial phenomena most favorable to its determination are of very rare occurrence, taking place at alternate intervals of eight and more than one hundred years. In order to profit by them it is necessary moreover that they should be simultaneously observed from stations on the earth the most widely distant from each other possible. On this account the governments of most civilized nations, in view of the importance and value of the results to be secured by the observation of these phenomena, have felt themselves justified in sending out large and costly expeditions to remote and often inhospitable regions, occupying in the preliminary preparations and subsequent supplementary observations many months and immense labor. Yet after all this lavish expenditure of money and time and physical toil and scientific skill, the distance of the earth from the sun continues to be uncertain to the extent of nearly a million of miles, or approximately the one-hundredth part. The same degree of uncertainty exists, therefore, in regard to the velocity of light as determined by astronomical methods.

A second astronomical method is derived from the aberration of light, a phenomenon detected by Bradley about a century and a half ago; but this depends again upon a previous knowledge of the rate of motion of the earth itself in its orbit, and brings us back once more to the sun's horizontal parallax.

The mechanical method of making the same determination has been attempted by two distinguished physicists, both well known for the ingenuity they have displayed in the prosecution of their numerous and various experimental researches. These investigators, both of them members of the French Academy of Sciences, occupied themselves almost simultaneously with this question between twenty and thirty years ago; but the mechanical contrivances employed by them for the purpose were different. Mr. Fizeau, the first to make the attempt, employed a rapidly-revolving toothed wheel, between the teeth of which a ray of light from a fixed radiant was sent to a distant mirror and returned by reflection to the eye of the observer stationed behind the wheel. If, during the passage of the ray to the mirror and back again, the rate of rotation of the wheel is such as to bring a tooth to occupy the place of the interspace through which the ray was transmitted, the returning light will be intercepted, and the image of the radiant will no longer be perceived. A greater or less velocity or rotation will make it once more perceptible. The velocity of rotation of the wheel being known for the moment when the intersection of the light is complete, and the distance of the mirror from the wheel having been carefully measured, this method should give the true velocity of light; and it would do so, provided the moment of extinction of the light were sharply defined. But this is not the case, the brightness fading away by degrees as the tooth gradually encroaches upon the path of the returning ray. Moreover, as the method requires a progressively increasing velocity in the rotation of the wheel, there is some difficulty in determining what is the exact velocity of rotation at the critical moment.

In these respects the contrivance employed by M. Foucault a few years later for the same purpose possesses decided advantages. M. Foucault made use of a rapidly revolving plane mirror, from which the image of a spider-line reticule reflected to a fixed concave mirror is, on the return of the light, a second time reflected into the direction of the originally incident beam. The change of position of the revolving mirror during the brief interval between the first and second reflections displaces the image seen by the reflected light, and the reticule appears to the observer to be double. The amount of displacement micrometrically measured furnishes the means of determining how great a change had taken place in the angular position of the mirror between the two reflections, and this, with the observed velocity of the mirror, gives the value of the same interval in time. Then, by measuring the distance between the two mirrors and doubling this, there is obtained the space passed over by light during this minute interval, and hence, by influence the space passed over per second, which the constant sought.

This method, however, like the first, has a disadvantage peculiar to itself. The image of the delicate lines of the reticule seen by reflection is too faint to be visible when the distance of the fixed mirror is great. Hence, in the actual application of the method by Foucault, the space passed over by the light for which the time of passage was determined amounted only to a few yards. Considering, therefore, that this time can hardly exceed the ten-millionth part of a second, it is obvious that the unavoidable errors of observation, however minute, must introduce some degree of uncertainty into the result obtained.

In the method of Fizeau the distance of the fixed mirror is not thus necessarily limited, but may be made as great as ten or twenty miles, or even more. The interval of time to be measured is still very small, perhaps as small as one four-thousandth or one five-thousandth part of a second; but this, in comparison with that above mentioned, is a large duration, and, with a wheel making six or eight hundred turns per second, it may be measured with a very close approach to exactness.

Professor Newcomb proposes to employ a method which embraces the advantages and excludes the disadvantages of the methods of both the distinguished French investigators. He would employ the revolving mirror instead of the toothed wheel, and would place the fixed mirror at the distance of several miles; substituting, in order that in this arrangement the object to be observed may not become invisible on account of the faintness of the returning light, a longitudinal opening or slit, illuminated by electricity or by the direct rays of the sun, instead of the spider reticule.

This will require the employment of two telescopes, one for transmitting the ray from its source, and the other for receiving it after reflection. The mirror will accordingly require to be somewhat elongated, and, encountering greater resistance, will probably revolve with less velocity than that employed by Foucault, but there will be the compensating advantage that a greater degree of precision in observation will be likely to be attained.

Professor Newcomb proposes to give to his mirror the dimensions three inches by six. It occurs to the committee to suggest that, since two telescopes are to be employed, there might be something gained in respect to convenience of arrangement by employing two mirrors also, the returning ray being received in a different azimuth from that of the ray sent out. Also that, with careful adjustment, it would seem practicable to reduce these mirrors to a size not exceeding two inches square each.

Upon a careful consideration of the proposition of Professor Newcomb, the committee are unanimously of opinion that, in case the experimental process is skillfully carried out, it promises to secure a result upon which a much more confident reliance can be placed than it is possible to give to any that has been hitherto reached in regard to the velocity of light.

By the astronomical method of Roemer, this velocity, after the transit of Venus of 1769, was fixed at 192,700 miles per second. If we assume the equatorial horizontal parallax of the sun to be 8″.83, which is about a mean between the various more recent determinations, a second astronomical method derived from the observed aberration of light gives a velocity of 185,200 miles.

The velocities obtained by Fizeau in successive experiments by his mechanical method were 196,000 miles and 194,000.

The velocities obtained by Foucault were 192,950 and 190,250 miles.

Those obtained by Cornu, employing the method of Fizeau, were, in 1873, with a fixed mirror distant about six and one-half miles, 185,490 miles; and in 1875, with the mirror distant more than fourteen miles, 186,460 miles.

It is easy to see how important in its relation to all the questions which concern the dimensions of the solar system and the magnitude of the masses composing it, as well as to those which involve the distances of the fixed stars and their absolute motions in space, must be an exact determination of the constant in question by a method wholly independent of astronomy.

The committee therefore concur in the opinion that the plan proposed by Professor Newcomb should, if possible, be carried into execution, as promising to reduce within very narrow limits the uncertainty which still exists in regard to this interesting and important element of our scientific knowledge.

In regard to the provision of means for securing the proper execution of the scheme, the committee are unanimously of the opinion that an application should be made to the Congress of the United States. The proposed investigation belongs to that class of inquiries for which enlightened governments have always esteemed it to be their proper province to provide. There is reason to believe that the result in this case will be to secure a more exact determination of the solar parallax than has yet been obtained, after all the labor and expense which have been bestowed on observations of the transits of Venus. It can hardly be doubted, therefore, that if the subject should be properly presented to Congress, that body, which has in a variety of ways hitherto done so much for the advancement of science, might be disposed to lend its aid to the accomplishment of this object also.

All of which is respectfully submitted.

NEW YORK, *January* 20, 1879.

F. A. P. BARNARD,
WOLCOTT GIBBS,
HENRY MORTON,
GEORGE F. BARKER,
E. C. PICKERING,
Committee.

To Prof. O. C. MARSH,
Acting President of the National Academy of Sciences.

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REPORT OF PROCEEDINGS

OF THE

NATIONAL ACADEMY OF SCIENCES

FROM NOVEMBER 16, 1880,

To the Close of the Year 1881.

WASHINGTON, D. C.:
JUDD & DETWEILER, PRINTERS.
1882.

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REPORT.

The National Academy of Sciences was established by act of Congress in March, 1863, with power to frame its own constitution, select its own members, and provide in other respects for its continuance and successful operation.

The object of the Academy is to advance science, pure and applied, by original researches; to invite the attention and aid of the Government to scientific inquiries of special importance, to be directed by the academy; and especially to investigate and report on any subject of science or art whenever called upon to do so by any department of the Government. It is also empowered by its charter to report to Congress on all matters needful or usual in such institutions.

The academy contains at present about one hundred members, representing nearly every department of knowledge, whose services, in accordance with the charter of the academy, are always at the disposal of the Government.

SESSIONS OF THE NATIONAL ACADEMY.

Since the last report of the academy, submitted to Congress May 1, 1880, it has held three sessions, viz., that convened at Columbia College, New York, November 16 to 19, 1880, which was devoted entirely to scientific work, the regular annual meeting held in Washington, April 19 to 22, 1881, and a stated session held in Philadelphia, November 15 to 17, 1881.

In conformity with the decision of the academy it is proposed that the present annual report to Congress shall include the proceedings of the three sessions above referred to, and that hereafter these annual reports shall be made to embrace the work of the academy from the beginning to the close of each calendar year.

SCIENTIFIC SESSION HELD IN NEW YORK CITY, NOVEMBER 16 TO 19, 1880.

At this session, held in rooms in Columbia College kindly provided for the use of the academy by the college authorities, the following members were in attendance:

Agassiz.
Baird.
Barker.
Barnard.
Chandler.
Coffin.
Cope.
Draper (H.)
Draper (J. B.)
Gibbs.
Gould.
Hall.
Hilgard.
Hunt.
Langley.
Marsh.
Mayer.
Morse.
Morton.
Newton.
Newberry.
Peters.
Pickering.
Rood.
Rutherford.
Silliman.
Scudder.
Trowbridge.
Trumbull.
Young.

In the absence of President Rogers, on account of illness, the meetings were presided over by Vice-President Marsh.

The following papers, twenty-eight in number, were read and discussed.

TITLES OF PAPERS.

1. Report on the Dredging Cruise of the United States Steamer Blake, Commander Bartlett, during the summer of 1880.—Alexander Agassiz.

2. On the intimate Structure of certain Mineral Veins.—Benjamin Silliman.

Remarks by Mr. Hunt.

3. Notes on the relations of the Oneonta and Montrose Sandstones with the Sandstones of the Catskill Mountains.—James Hall.

4. On a new general method of analysis.—Wolcott Gibbs.

Remarks by Mr. Hunt.

5. On some recent experiments in determining the electromotive force of the Brush dynamo-electric machine.—Henry Morton.

6. Measurement of new form of Electric Lamps operating by Incandescence.—Henry Morton.

Remarks by Messrs. Gibbs and Barker.

7. On the Phenacodontidæ.—E. D. Cope.

Remarks by Mr. Newberry.

8. On the Mimoravidæ and Canidæ of the Miocene Period.—E. D. Cope.

9. On the Basin of the Gulf of Mexico.—J. E. Hilgard.

10. On the origin of the Coral Reefs of the Yucatan and Florida Banks.—Alexander Agassiz.

The subjects of these two papers were discussed by Messrs. Guyot, Morse, Coffin, and Newberry.

11. Observations on Ice and Icebergs in the Polar Regions.—By Lieut. F. Schwatka, U. S. A., at the invitation of the academy.

12. On the Duration of the Arctic Winter.—By Lieut. F. Schwatka, U. S. A., at the invitation of the academy.

Remarks by Mr. Guyot.

13. Mineralogical Notes.—Benjamin Silliman.

Remarks by Messrs. Newberry and Morse.

14. The relationship of the Carboniferous to living and extinct Myriapods.—Samuel H. Scudder.

Remarks by Messrs. Agassiz and Morse.

15. On measurement of Radiant Energy.—S. P. Langley.

Remarks by Mr. Young.

16. On the Bolometer.—S. P. Langley.

Remarks by Mr. Barker.

17. Causes which determine the progressive movements of storms.—Elias Loomis.

Read by home secretary.

18. On the Antimony Mines of Southern Utah.—J. S. Newberry.

Remarks by Messrs. Brush and Brewer.

19. On the Conglomerate Ore Deposits of the United States and Mexico.—J. S. Newberry.

20. On an improvement in the Sprengel Air-pump.—O. N. Rood.

21. On the deposits of Crystalline Ores in Utah.—J. S. Newberry.

22. On the Origin of Anthracite.—T. Sterry Hunt.

Read by Mr. Newberry.

Remarks by Mr. Newberry.

23. On the Star List of Abul Hassan.—C. H. F. Peters.

Remarks by Mr. Coffin.

24. On photographing the Nebula in Orion.—Henry Draper.

Remarks by Messrs. Rood, Pickering, and Langley.

25. On Condensers for Currents of high potential.—George F. Barker.

Remarks by Mr. Langley.

26. On Sigsbee's Gravitating trap.—Alexander Agassiz.

27. On the ellipticity of the Earth as deduced from pendulum experiments.—Charles S. Pierce.

Read by Mr. Langley.

Remarks by Messrs. Peters, Agassiz, and Langley.

28. Dimensions of the Brain and Spinal Cord in some extinct Mammals.—O. C. Marsh.

The vice-president announced the death, since the last meeting of the academy, of the following members: Jonathan Homer Lane, of Washington, D. C., May 3, 1880; Lewis F. Pourtales, of Cambridge, Mass., July 19, 1880; Samuel S. Haldeman, of Chickies, Pa., September 20, 1880.

Messrs. J. E. Hilgard, Alexander Agassiz, and John L. Le Conte were selected to prepare biographical memoirs of the deceased members, respectively, in the order above stated.

Mr. Le Conte having subsequently declined the task assigned him, Mr. J. P. Lesley was chosen to prepare the memoir of Mr. Haldeman.

Mention was also made of the death of Prof. Benjamin Peirce, at Cambridge, Mass., who, though not recently associated with the academy, was one of its original members, and has been until within a few years an active participant in its labors.

A few days after the close of this meeting the academy was deprived of another of its members by the death of James Craig

Watson, director of the Washburn Observatory, Madison, Wis., who died on November 23, 1880. Mr. J. E. Hilgard has been requested to prepare a biographical memoir of Mr. Watson, to be presented to the academy, and has signified his willingness to do so.

TRUSTEE OF TYNDALL FUND.

The vacancy created in the board of trustees of the Tyndall Fund by the death of General Hector Tyndall, of Philadelphia, has been filled by the appointment, May, 1880, by the President of the Academy, of Prof. Joseph Lovering, of Cambridge.

In closing the session a resolution was adopted conveying the thanks of the academy to the trustees of Columbia College for their courtesy in providing rooms for its sessions, and to President Barnard and the officers of Columbia College, as well as to the other members of the academy in New York, for their hospitable entertainment.

The academy then adjourned to meet in the city of Washington on April 19, 1881.

RESTORATION AND PRESERVATION OF THE MANUSCRIPTS OF THE DECLARATION OF INDEPENDENCE.

A communication was received May, 1880, from the Secretary of the Interior, Hon. Carl Schurz, as chairman of a committee appointed by act of Congress, requesting—

> The president of the National Academy of Sciences to appoint from among the members of the academy a committee to inquire into the practicability of restoring the faded writing of the original manuscript of the Declaration of Independence, and to report what measures, if any, can be adopted for its restoration, as well as how it may best be protected against further injury.

In compliance with this request the following members of the academy were appointed a committee for the object referred to, namely, Wolcott Gibbs, J. E. Hilgard, C. F. Chandler, R. E. Rogers, J. L. Smith.

After a careful investigation of the questions involved, the committee agreed upon the following report, which was trasmitted to the Hon. Carl Schurz, Secretary of the Interior, January 18, 1881:

Report of the committee of the National Academy of Sciences on the restoration of the manuscript of the Declaration of Independence.

Prof. Wm. B. Rogers,
President of the National Academy of Sciences:

Sir: The committee of the National Academy of Sciences, to which was referred the question of the restoration of the faded writing of the original manuscript of the Delaration of Independence, respectfully reports:

That, in the judgment of the committee, it is not expedient to attempt to restore the manuscript by chemical means, partly because such methods of restoration are at best imperfect and uncertain in their results, and partly because the committee believes that the injury to the document in question is due, not merely to the fading of the ink employed, but also and in a large measure to the fact that press copies have been taken from the original, so that a part of the ink has been removed from the parchment.

The committee is therefore of the opinion that it will be best, either to cover the present receptacle of the manuscript with an opaque lid or to remove the manuscript from its frame and place it in a portfolio, where it may be protected from the action of light; and furthermore that no press copies of any part of it should in future be permitted.

Wolcott Gibbs, *Chairman.*
J. E. Hilgard,
J. Lawrence Smith.
R. E. Rogers.
C. F. Chandler.

Boston, *January* 7, 1881.

STATED SESSION HELD IN WASHINGTON, APRIL 19, 1881.

The meetings were held in All Souls church, the President, Wm. B. Rogers, in the chair.

The following members were in attendance:

Abbe.
Abbot.
Baird.
Barker.
Coffin.
Cope.
Cooke.
Chandler.
Ferrel.
Gill.
Guyot.
Hall, (Asaph.)
Hilgard.
Humphreys.
Hill.
Hunt.
King.
Langley.
Marsh.
Meigs.
Morse.
Newcomb.
Peters.
Powell.
Peirce.
Rogers, (Wm. B.)
Rodgers, (John.)
Rogers, (Fairman.)
Schott.
Schudder.
Silliman.
Walker.
Warren.
Wood.
Woodward.

LETTER FROM THE PRESIDENT OF THE UNITED STATES.

After a brief welcome from President Rogers, a letter was laid before the academy from his excellency President Garfield, acknowledging an invitation from the president of the academy to attend its meetings, and expressing the hope that he would be able to do so, and also appointed Thursday evening, April 21, as the time for the reception of the academy at the White House.

APPOINTMENT OF A COMMITTEE ON METEOROLOGY.

A communication was laid before the academy from General William B. Hazen, Chief Signal Officer, United States Army, under date of April 4, 1881, asking that a permanent committee be appointed with whom the Signal Officer might confer from time to time as to the best means of advancing the science of meteorology and its applications to the benefit of agriculture and commerce.

The following-named members were thereupon appointed by the president a committee on meteorology to confer and co-operate with the Chief Signal Officer: Mr. Newcomb, chairman, and Messrs. Loomis, Gibbs (W.), Newton (H. A.), Ferrel, Schott, and Langley.

was entirely personal, the courts of the latter had exclusive jurisdiction of the bequest.

As none of the executors named in the will are residents in Wisconsin, and as they are widely scattered, it will be difficult for more than one to act, and the administration will have to be conducted under the direction of the probate court at Madison.

It is difficult to see what amount, if any, the academy will ultimately receive for the purposes desired by the testator, owing to two causes: the unsettled condition of several business enterprises in which our colleague had invested much of his means, and the indefinite character of his business arrangements with the University of Wisconsin. The only item of the estate to which even an approximate cash value *can* be assigned consists of stock and policy in the Mutual Life Insurance Company of Michigan, the total value of which probably amounts to about $30,000.

The next item in importance is the Printing and Publishing Company of Ann Arbor, of which the deceased owned 499 shares out of the total of 500. The actual cost of this stock was about $26,000, but the property at present owned by the company is of so miscellaneous a character and it is so complicated by litigation as to make it hardly possible even to guess at the value of its assets.

I judge, however, from a general examination of its property, that should the company go into liquidation it might realize anywhere from $5,000 to $15,000, but a debt of $5,000 is due from it, so that the net amount may range from zero to $10,000, the lower ultimate being more probable than the upper one.

The next item in importance is the Chase Publishing Company of Toledo, which is said to be profitable, but to it no definite value can be assigned.

On the other hand, our colleague at Madison expended considerable sums on improvements of the observatory and its grounds, without any distinct understanding with the board of regents as to who should ultimately bear the expense. These improvements include the Watson solar observatory, the students' observatory, the fitting up of the director's house, the purchase of the transit instrument, and several other items. An amount of between $5,000 and $10,000 is, I believe, due on these various improvements, so that if the estate is to pay for them all it will be materially diminished.

I may also add that, under the laws of Wisconsin, Mrs. Watson is entitled in lieu of the provision made for her in the will to accept one-third of the net proceeds of the estate. It has been suggested that in the event of the estate not realizing the amount expected an arrangement should be made with Mrs. Watson to allow her the entire income from it during her life on condition of the entire amount reverting to the academy on her death This arrangement will probably commend itself if the amount shall be found insufficient to carry out the objects which our lamented colleague had at heart in making the bequest.

The matter of the action of the academy on the Watson bequest was referred to the council.

INVITATIONS.

Professor Newcomb invited the members of the academy to view his apparatus for measuring the velocity of light, in operation at Fort Myer.

A letter was received from Admiral and Mrs. John Rodgers, inviting the members of the academy and their families to a reception at the Naval Observatory on Wednesday evening, the 20th instant, at eight o'clock.

Also, an invitation from President and Mrs. Rogers to attend a reception at Wormley's Hotel on Thursday evening, immediately after the reception at the White House.

An announcement was made that there would be a meeting of the Anthropological Society at the Columbian College on the evening of the 19th, to which the members of the academy were invited.

A communication was received from the secretary of the Cosmos Club of Washington, inviting the members of the academy to make use of the club-house during their stay; and from the Hon. Mr. Corcoran, to visit the Corcoran Gallery of Art and the Washington Monument.

SCIENTIFIC PROCEEDINGS.

At the opening of the scientific session, April 19, President Rogers delivered an address on "The Recent Progress in some Departments of Physical Science," which was followed by the reading of scientific papers.

The following is a list of the scientific papers presented to the academy during the several days of its session, beginning April 19

LIST OF PAPERS.

1. On the domain of Physiology.—T. Sterry Hunt.

Remarks by Mr. Cope.

2. The Compass Plant of the Western Prairies.—By General E. Alvord, at the invitation of the academy.

3. The Solar Constant.—S. P. Langley.

4. The Color of the Sun.—S. P. Langley.

5. On Mountain Observations.—S. P. Langley.

6. On the relations of Soils to Health.—R. Pumpelly.

7. Reduction to Sea level of Barometric Observations made at elevated stations.—Elias Loomis.

Read by Mr. Abbe?

Remarks by Messrs. Abbé, Peters, and Meigs.

8. On Electric Light Photometry.—George F. Barker.

Remarks by the president.

9. On the condenser method of measuring high tension currents.—George F. Barker.

Remarks by Mr. Abbot.

10. On the relations between strains and impacts and the structure of the feet of the Mammalia.—E. D. Cope.

Remarks by Mr. Morse.

11. On the progress of pendulum work.—C. S. Peirce.

12. On the carbon lamp fiber in the thermo-balance.—George F. Barker.

Remarks by Mr. Langley.

13. Upon the production of Sound by radiant energy.—By Mr. A. Graham Bell, at the invitation of the academy.

Remarks by the president.

14. On the later Tertiary of the Gulf of Mexico.—E. W. Hilgard.

Read by Mr. Pumpelly.

15. On the Utilization of the Sun's Rays in heating and ventilating.—Edward S. Morse.

Remarks by Messrs. Hilgard, Coffin, and the president.

16. Recent researches in the vicinity of Bering's Strait, comprising—

I. An account of the land ice of Kotzebue Sound and the Arctic Coast.—W. H. Dall, at the invitation of the academy.

Remarks by Messrs. Pumpelly, Morse, Guyot, and the president.

17. II. Additions to our knowledge of the Currents and Temperature of the Ocean in the vicinity of Bering's Strait—W. H. Dall, at the invitation of the academy.

Remarks by Messrs. J. E. Hilgard and Guyot.

18. Results just obtained with regard to the Molecular weight of Hydro-fluoric acid.—J. W. Mallet, at the invitation of the academy.

Remarks by Mr. Barker.

19. A method for finding the proximities of the Orbits of Minor Planets.—C. H. F. Peters.

20. On Incandescent Lights.—George F. Barker.

21. On the Auriferous Gravels of California.—T. Sterry Hunt.

BIOGRAPHICAL MEMOIR.

At the meeting on April 21 a biographical memoir of Louis F. Pourtales, prepared by Mr. Agassiz, was read by Mr. Guyot, the author being absent.

VISIT OF THE PRESIDENT OF THE UNITED STATES.

While the reading of the papers was in progress, on the last day of the session, President Garfield entered the room, and at the invitation of the president of the academy, occupied a seat upon the platform, where he remained until the close of the meeting.

RESIGNATIONS.

Mr. Fairman Rogers having resigned the office of treasurer, which he had held for sixteen years, and Mr. Coffin that of home secretary, resolutions were adopted thanking these officers for their faithful services.

ELECTIONS.

Mr. Simon Newcomb was elected to the office of home secretary of the academy in place of Mr. J. H. C. Coffin, resigned.

Mr. J. H. C. Coffin was elected treasurer of the academy in place of Mr. Fairman Rogers, resigned.

The following members were elected to the Council for the ensuing year:

Gibbs, (W.)
Hall, (A.)
Baird, (S. F.)
Hilgard, (J. E.)
King, (C.)
Rogers, (F.)

The *new members* elected were H. A. Rowland of Johns Hopkins University, Baltimore, and Arthur W. Wright of Yale College, New Haven.

AMENDMENTS TO CONSTITUTION AND RULES.

The pending amendment to Section 4, Article IV, of the constitution was adopted, making the section read as follows:

Nomination of members and foreign associates may be made in writing, signed by any five members of the academy, at any stated session, to be voted on at the next stated session *to be held in Washington.*

Section 5, Article IV, was adopted, as follows:

Elections for membership shall be held in the following manner: Each member may inscribe on a ballot not more than five names of nominees selected from the list. Absent members may send such ballots to the home secretary. From the seven names receiving the highest number of votes in this preference ballot, the members present may proceed to elect new members in the following manner: At each ballot each member present may vote for not exceeding three persons, and the person receiving the highest number of votes shall be declared elected, provided that he receive two-thirds of the votes cast and his name appear on not less than twenty ballots; and provided further, that the number of members of the academy be not already one hundred or over, in which case to be declared elected he must receive four-fifths of the votes cast, and his name must appear on at least twenty-five ballots.

Should several candidates have the same minimum number of votes on the preference list, the requisite number for completing the list shall be selected from them by a two-thirds vote of the members present.

Elections of members shall be held only at the regular stated session of each year held in Washington, and not more than five members shall be elected at that session.

Before and during elections a discussion of the merits of nominees will be in order.

The election of members may be suspended at any time by a majority vote of the members present.

This amendment restricts the election to the seven names receiving the highest number of votes in the preference ballot; requires not less than twenty ballots to elect if the number of the academy shall not thereby be increased above one hundred, and not less than twenty-five ballots if the number shall be increased above one hundred.

The council having recommended that the second clause of the regulation amending Rules XI and XIII, on printing, adopted at the last April session, be amended so as to read, "Not later than one month after" instead of "at the meeting," this amendment was adopted.

The following amendment to Section 1, Article I, was recommended by the council for adoption, to be voted on at the next stated session, viz:

Amend Section 1, Article I, by adding the words, "members shall be citizens of the United States or have declared their intention to become so."

RESOLUTIONS OF THANKS, ETC.

A resolution was passed thanking the trustees of All Souls' Church for their courtesy in granting the use of their building to the academy for its meetings.

Also, resolutions were passed expressing the thanks of the academy to the Hon. W. W. Corcoran, for his invitation to visit the Corcoran Gallery and the Washington Monument; and to the Anthropological Society and Cosmos Club of Washington, for their kind invitations to members of the academy.

The academy adjourned on Friday, April 22, to meet in stated session in Philadelphia on November 15, 1881.

ADVISORY COMMITTEE ON THE COMING TRANSIT OF VENUS.

The British Minister at Washington in a communication to our Government, dated April 11, 1881, stated that the lords commissioners of Her Majesty's treasury have deputed to a committee of the Council of the Royal Society of London the preliminary duty of reporting to Her Majesty's Government for approval what arrangements should be made, so far as Great Britain is concerned, for taking part in the observations of the approaching Transit of Venus, and that said committee is desirous of knowing what part in the same work is to be undertaken by foreign governments who are likely to take active steps for observing the Transit.

This communication was transmitted by the Secretery of the Navy of the United States to Rear-Admiral John Rodgers, the Superintendent of the United States Naval Observatory, who is the president of the commission appointed by our Government some years since to make arrangements for the observations of the Transit of Venus of 1874, and matters relating thereto.

This commission, which is regarded as still in force, being desirous to take measures as early as practicable to prepare for the observations by American astronomers of the Transit of 1882, has, through its president, the Superintendent of the United States Naval Observatory, requested me, as president of the National Academy of Sciences and as a member of said commission, to nominate ——— members of the academy, who shall form an advisory committee to co-operate with the commission in determining the best methods of observing the approaching Transit, as well as the stations to be occupied and the instruments to be used.

In conformity with the request of the Superintendent of the United States Naval Observatory, the following members of the Academy have been designated as a committee to aid the commission in the preparatory work referred to:

Prof. C. H. F. Peters, Litchfield Observatory, Clinton, N. Y.
Prof. S. P. Langley, Allegheny Observatory, Pittsburgh, Pa.
Prof. E. C. Pickering, Harvard College Observatory, Cambridge, Mass.
Prof. C. A. Young, Princeton College, Princeton, N. J.
Prof. H. A. Newton, Yale College, New Haven, Conn.
Prof. Henry Draper, New York.

These gentlemen have signified their willingness to serve on the committee.

STATED SESSION HELD IN PHILADELPHIA, NOVEMBER 15 TO 17, 1881.

The meetings of this session were held at the University of Pennsylvania, in rooms kindly provided by the authorities of the University.

The following members were in attendance:

bbe.
gassiz.
aird.
arker.
handler.
ope.
Draper, (H.)
Genth.
Gibbs, (W.)
Gill.
Hayden.
Langley.
Lesley.
Le Conte, (J. L.)
Marsh.
Mitchell.
Morse.
Morton.
Peirce.
Pumpelly.
Rodgers, (J.)
Rogers, (F.)
Rogers, (R. E.)
Rogers, (W. B.)
Rowland.
Silliman.
Trumbull.
Walker.
Wood.
Young.

The academy was called to order by the president at 12 o'clock. The home secretary, Mr. Newcomb, being absent, Mr. Barker was appointed secretary *pro tem.*

After the reading by the secretary of the report of the April meeting of the academy, and its approval, the president announced the following members as the local committee for the session: Barker, Cope, Genth, Hayden, Le Conte, Leidy, Lesley, Rogers, F., Rogers, R. E., Sellers, and Wood.

Mr. Barker announced that General Thomas Eckert, of the Western Union Telegraph Company, and President N. J. Phillips of the American District Telegraph Company, had offered to the members of the academy the use of their respective services, both telegraph and messenger, during the present session.

SCIENTIFIC PROCEEDINGS.

The president in opening the scientific session made a brief reference to some points of recent scientific interest, after which the reading of papers was begun.

The following are the titles of the papers (twenty-one in number) presented to the academy during the several days of its session:

LIST OF PAPERS.

1. On a gigantic Salpa from the Gulf Stream.—A. Agassiz.

Remarks by Mr. Morse.

2. The Echini of the Challenger Expedition.—A. Agassiz.

3. Classification of the Dinosauria.—O. C. Marsh.

Remarks by Mr. Cope.

4. Mean annual rainfall for different countries of the Globe.—Elias Loomis.

Read by the secretary.

5. The Proportidæ and Velellidæ and the Surface Fauna of the Gulf Stream.—A. Agassiz.

Remarks by Mr. Morse.

6. On Complex Inorganic Acids.—W. Gibbs.

Remarks by Messrs. Genth and Barker.

7. On the Phenacodontidæ, a new group of Perissodactyla.—E. D Cope.

Remarks by Mr. Marsh.

8. Succession in time of the Allotheria.—O. C. Marsh.

Remarks by Mr. Cope.

9. The distribution of the Corals of the Tortugas.—A. Agassiz.

Remarks by Mr. Silliman.

10. A comparison between the shells of Kjökkenmöddings and present shells of the species.—E. S. Morse.

Remarks by Messrs. Marsh and Cope.

11. On a form of Regulator for the driving clock of an Equatorial.—C. A. Young.

12. On the objects and results of the recent Expedition to Mount Whitney.—S. P. Langley.

Remarks by Messrs. Rowland, Gibbs, Agassiz, and Abbe.

13. Notice of a remarkable mineral vein in the Black Range (Negretta Mountains) of Socorro County, New Mexico.—B. Silliman.

14. Statement respecting experiments on the Velocity of Light.—Simon Newcomb.

Read by the secretary. (See page — of present report.)

15. On the Logic of Number.—C. S. Peirce.

16. On Hydrometer Scales.—C. F. Chandler.

Remarks by Messrs. Peirce and Silliman.

17. On Chinoline, its synthesis and medical uses.—Henry Morton.

Remarks by Mr. Abbe.

18. On the Theory of the Dynamo-electric Machine.—W. Gibbs.

Remarks by Messrs. Rowland, Morton, and Baker.

19. Facts regarding Sorghum and some conclusions as to its value as a source of Sugar.—Peter Collier, presented by Mr. Silliman, at the invitation of the academy.

Remarks by Messrs. Chandler and Abbe.

20. On Mascart's Electrometer and its use as a Meteorological Instrument.—G. F. Barker.

Remarks by Messrs. Abbe and Rowland.

21. On the Fossil and recent Faunæ of the Oregon Desert.—E. D. Cope.

22. On a new form of Volumescope.—R. E. Rogers.

23. The newly determined line of the Terminal Moraine across Pennsylvania.—J. P. Lesley.

The last two named papers, though entered on the list of the secretary, were not read.

BIOGRAPHICAL MEMOIR.

At the meeting on November 16, a biographical memoir of the late S. F. Haldeman, prepared by Mr. J. P. Lesley, was read by the author.

REPORT OF PROGRESS IN THE EXPERIMENTS ON THE VELOCITY OF LIGHT.

It is now about three years since the academy recommended an appropriation for a determination of the velocity of light on a larger scale than any before attempted. In accordance with this recommendation an appropriation was made in 1879, and the writer was assigned to the supervision of the experiments. They have now reached a stage when a definite report of their progress can be made.

The apparatus, though founded on well-known principles, was in its construction and arrangement entirely new. Its completion was therefore a somewhat tedious process, in view of the precautions necessary at every step to avoid mistake. It was therefore not until the summer of 1880 that it was actually mounted and got into operation.

A selection of a site offered great difficulties. It was necessary—

1. To have a nearly horizontal line of sight two miles in length, more or less, and so high above the ground that the atmospheric disturbances should not be seriously perceived.

II. To have both ends of the line under some form of public protection, convenient of access, and free from interruption.

The station selected as the main one was Fort Whipple, now Fort Myer, west of the Potomac. The great advantage of this station was its height, in consequence of which different points in the city of Washington could be selected, the rays of light from which would pass over the Potomac at an elevation ranging from 100 to 150 feet. Its disadvantage was a distance of four miles from the central parts of Washington City.

The station first chosen for the distant reflector was upon the grounds of the Naval Observatory. Between Fort Meyer and the Observatory we succeeded during the summer and autumn of 1880 in making nearly a hundred sets of measures, the deviations ranging from 4° to 6°.

Besides the regular measures on the rays of light two subsidiary determinations were of equal importance. One was a triangulation to determine the exact distance of the two stations; the other, the determination of the value in arc of the divisions under the microscopes of the instruments. The first determination was made under the auspices of the Coast Survey, by Assistant Sinclair, with the assistance of Midshipman J. H. L. Holcomb, United States Navy.

Mr. Sinclair also made a determination of the value of one division of the photolachometer by the aid of the theodolite.

In the spring of 1881 a few more determinations were made between the same stations. The fixed mirrors were then removed to a station at the base of the Washington Monument, in order to make a new set of measures at a greater distance. The distance to the Observatory was, in round numbers, 2,550 meters; that to the Monument 3,720 meters. Great difficulties were, however, experienced in getting the apparatus into actual operation on the new line of sight. The adjustment of the mirrors had to be much more precise than when they were at the Observatory, not only on account of the long line of sight, but because the curvature of the mirrors corresponded more nearly to the greater distance, which rendered a more exact adjustment necessary. The pier on which the mirrors rested at the Monument was built on recently-made ground, so that for the first two months they were very unstable. Moreover, the rays were more obscured by smoke at the greater distance. Notwithstanding these drawbacks, when all the adjustments were successfully made, and the atmosphere was quite clear, the image was as well seen from the Monument as it had been from the Observatory. The angle of deviation on which the velocity depended was now increased to 8°.

The results are not yet completely worked up, as it is necessary to combine the separate observations on some well-established uniform plan. The following preliminary results from the three series will, however, so far as yet known, be subject to but slight alterations:

	Kilometers per second.
Summer of 1880, to Observatory	299,680
Spring of 1881, to Observatory	299,720
Autumn of 1881, from Monument	299,750

These results are so embarassing, from two causes, that I hesitate about publishing them. In the first place they are on the average more than 200 kilometers or $\frac{1}{1500}$ part less than those of Mr. Michelson. Now, the latter aimed at permitting no source of error to creep in which could possibly amount to $\frac{1}{10000}$ part of the whole, and from a careful examination of his work I am unable to assign any probable cause of error which should have affected it by even 50 kilometers. It is true there are two points connected with his work which I have not yet been able to examine. One is a possible inclination of the reflecting surface of his mirror to the axis of rotation. This axis was not independently adjusted to verticality in his experiments, but was adjusted to throw the reflected ray along a certain path as the mirror revolved. If there were any lack of parallelism between the reflecting surfaces and the axis of rotation it might materially affect his results. The other point is the distance of his station. This distance was measured four times with a steel tape line, and although it seems scarcely possible that any systematic mistake should be made in this, in view of the care which Mr. Michelson must have devoted to the work, yet his description of his process is not so explicit that a scientific jury could pronounce the measure absolutely free from the possibility of error.

The next circumstance which will be remarked is that the systematic differences between my results as given above so far exceed their probable error as to show beyond doubt that some or all of them are affected by systematic error of some kind. What the source of error may be I am unable to say with certainty. In fact I had supposed every possible source of such error to be so thoroughly guarded against that, during the whole course of the experiments, I neglected certain precautionary investigations of the apparatus which I now see should have been made. My attention was first called to this necessity in the spring of 1881 by noticing that the images from the four faces of the revolving mirror did not always lie in the same vertical line. At length, in August, I one day observed, when the mirror was at high speed, that a set of two images separated themselves by, I should judge, one or two minutes from the other two. When the effect was thus increased the cause flashed upon me in a moment. The mirror in revolving was undergoing a torsional vibration, the period of which was some submultiple of that of revolution. This occurred just after making some dangerous alterations in one of the fan-wheels. I therefore sent the mirror to the Messrs. Clark to have its pivots examined and its balance tested. Mr. George Clark found it to be not only slightly out of balance, but the pivots to be worn somewhat out of round. As I was anxious to complete the experiments, he returned it immediately without regrinding the pivots. But the evil was as great as ever. I therefore returned it to him to have the pivots reground at the watch factory.

Attention was now given to another source of error. If the revolution of the mirror was accompanied by any torsion, the result for the velocity of light would be affected thereby. This had been forseen from the beginning; and to avoid it, fan-wheels had been placed on both ends of the mirror, so that being driven equally at both ends no torsion should have place. It now occurred to me that the exceedingly small torsion necessary to produce a considerable systematic error might still be possible. I therefore made arrangements for investigating the motion of the mirror by means of a reflector in its immediate neighborhood. The absolute effect of torsion would be as great from this near mirror as from the distant one. After the pivots were reground the mirror was found to run better than ever and to be free from any sensible torsional vibration. To put the question of systematic torsion to as severe a test as possible, several experiments were made by running the mirror with only a single fan-wheel. The torsion, measured from the near mirror, was so slight that systematic error from that source scarcely seems possible. The concluding experiments have been made only within the last few days, and are not yet worked up, so that I am unable to present definitive results. I can only say that I have thus far been unable to detect any possible source of systematic error which could affect the result by so much as 100 kilometers.

The season is now so far advanced that no further investigations can be made until spring. It is, then, essential to the final success of the experiments that every source of possible systematic error shall be carefully investigated. But the appropriation made by Congress is now exhausted, and a new one will be necessary to go on with the experiments. I may add that the original estimated cost of the whole work was $7,000, of which only $5,000 has thus far been appropriated and expended. The remaining $2,000, if appropriated, will amply suffice for the purpose in view, and I hope the academy will sustain me in recommending to the Secretary of the Navy that Congress be asked to appropriate that sum at the coming session.

I may add in the way of general remark that the whole of the operations have proved excessively tedious; far more so than expected, from several causes. One is the fact that the measures, especially at the greater distance, can only be made with a cloudless sun and an exceptionally clear atmosphere. Accordingly, a large part of the day is frequently spent in waiting for clouds to clear away, or unavailing attempts to see the image through a smoky atmosphere. Another drawback is the distance from the center of the city to the seat of the apparatus, rendering necessary an eight-mile drive for the smallest operation that may be required. These drawbacks are, however, absolutely unavoidable, and are mentioned principally to account for the great time which has been consumed in the experiments.

I feel also that some explanation is due of my failure to make an early investigation of possible sources of systematic error. The reason is that the introduction of any new mechanism, such as is required for this purpose, disarranges the apparatus and renders a new adjustment necessary when the regular observations are to be made. They were, therefore, postponed until the necessity was apparent. Unfortunately this did not occur until it was to late to carry them out with our present means.

It may also be remarked that much more time has been consumed on these than on any previous similar experiments. I should reply to this that I doubt if any physicist ever conceived of even the possibility of making the measurements of the velocity of light depend upon that of an arc so great as 8°, or of seeing a return flash in a revolving mirror from a distance of 2½ English miles.

S. NEWCOMB.

WASHINGTON, *November* 15, 1881.

AMENDMENT TO THE CONSTITUTION.

The amendment to section 1, Article 1, approved at the meeting of the academy April, 1881, proposing to add at the close of the original sentence the words "members shall be citizens of the United States or shall have declared their intention to become so," was not adopted; but, as a substitute, the following amendment was adopted in committee of the whole, to be voted on at the next stated session:

A candidate for membership in the academy must be a citizen of the United States.

RESOLUTIONS.

The following resolution was offered by Mr. Silliman and referred to the council:

Resolved, That the subject of sorghum sugar, the experimental results on which, obtained during the three or four years last past by Dr. Peter Collier, of the Agricultural Department, submitted in brief, by invitation, to the academy at its Philadelphia session in November, 1881, is, in the opinion of the academy, of sufficient importance to be referred to a committee of chemists, members of this academy, with the request that they give Dr. Collier's results and methods a careful consideration, and report at their early convenience the conclusions to which they come.

The following resolution was offered by Mr. Chandler and referred to the council:

Resolved, That a committee be appointed by the academy, to consider what action, if any, is desirable, with a view to establishing a legal value for the degrees of the Beaumé and other hydrometers of arbitrary scales; the committee to report at the next meeting.

Both these resolutions were approved by the council, whereupon the president appointed the following members of the academy to constitute the committees referred to:

On sorghum sugar, Messrs. Silliman, Johnson, Chandler, and L. Smith.*

On hydrometer scales, Messrs. Chandler, Hilgard, and Morton.

On motion of Mr. Barker it was—

Resolved, That the National Academy of Sciences cordially approves of the formation of an international commission on electrical units, as suggested by the Paris Electrical Congress, and earnestly hopes that the necessary appropriation may be made by the Congress of the United States to enable the members of this academy already appointed on this commission, through the Department of State, to carry out the needed experimental determinations with credit to the country.

Resolutions were adopted thanking the trustees and faculty of the University of Pennsylvania for the use of the building during the meeting of the academy, and to the Academy of Natural Sciences of Philadelphia for placing its facilities at the service of the National Academy.

A resolution was adopted thanking the Western Union Telegraph Company and the American District Company for the use of their respective services.

At 3 p. m. the academy adjourned to meet in Washington on the third Tuesday of April next, (April 18, 1882.)

It was intended, in accordance with the decision of the academy at the meeting of April last, to include in the present report, along with the proceedings and special reports heretofore usually published, all the scientific papers, either in full or in abstract, as the case might be, which have been presented and accepted at the several meetings to which the report relates. It has been found, however, that this intention could not now be carried out, as, from insufficient notice and other causes, only a few of the papers read before the academy have been furnished for incorporation in the report. It is nevertheless confidently expected that in future annual reports the scientific work of the academy will be fully set forth in the way proposed.

This new feature of the reports of the academy is so obviously essential to a proper representation of its labors as a scientific body, and therefore of its operations as contemplated in its charter, that it must, we think, be regarded as an authorized if not a required part of the annual report expected from it by the Government.

As regards the publication of these larger and complete reports, it may be added, that, although the investigations of the members of the academy are in general accessible in the scientific journals or the proceedings of other societies, such a collected publication of its scientific transactions as that proposed seems to be demanded by a regard to the rank of the academy among the scientific organizations of the country and the importance of its labors, as well as by its peculiar responsibility as a scientific adviser of the Government.

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*Since the meeting of the academy the Commissioner of Agriculture, Hon. George B. Loring, having been informed by the president of the Academy of its action as above stated, has forwarded to him the documents on the subject, with the request that they be submitted to a committee of the academy for examination, adding, "that if this reference involves a scientific investigation of the sorghum question he will be greatly obliged for the report." These documents have been placed in the hands of the committee for the purpose.

This Committee was enlarged by adding W. H. Brewer, a member of the *Academy, and C. A.* Goessman and Gideon E. Moore, not members.

In conclusion, I may be allowed to say that, inasmuch as the academy is at all times ready to respond to the official calls made upon it for scientific service, and as its members do not receive compensation for the time and labor expended by them in such investigations, we feel warranted in assuming that the Government will willingly authorize the additional expense attendant on the publication of its scientific papers as part of its annual report.

WILLIAM B. ROGERS,
President National Academy of Sciences.

APPENDIX A.

AN ACT to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, U. S. A., Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, U. S. N., Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, U. S. N., Massachusetts; George Engelmann, Saint Louis, Mo.; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, U. S. N., Kentucky; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, U. S. A., Pennsylvania; J. L. Le Conte, U. S. A., Pennsylvania; J. Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, U. S. N., Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania: W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, jr., Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, U. S. A., Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate by the name of the National Academy of Sciences.

SEC. 2. *And be it further enacted,* That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or useful in such institutions, and to report the same to Congress.

SEC. 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the academy shall receive no compensation whatever for any services to the Government of the United States.

Approved March 3, 1863.

AN ACT to amend the act to incorporate the National Academy of Sciences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act to incorporate the National Academy of Sciences, approved March 3d, eighteen hundred and sixty-three, be, and the same is hereby, so amended as to remove the limitation of the number of ordinary members of said academy as provided in said act.

Approved July 14, 1870.

APPENDIX B.

ORGANIZATION OF THE NATIONAL ACADEMY OF SCIENCES.

OFFICERS.

	Expiration of term.
President, William B. Rogers	1885
Vice-President, O. ~~W~~. Marsh	1884
Foreign Secretary, Alexander Agassiz	1886
Home Secretary, Simon Newcomb	1887
Treasurer, J. H. C. Coffin	1887

COUNCIL.

Wolcott Gibbs.
Fairman Rogers.
Asaph Hall.
S. F. Baird.
J. E. Hilgard.
Clarence King.

COMMITTEES.

Committee on Weights, Measures, and Coinage.—F. A. P. Barnard, Henry Draper, Wolcott Gibbs, J. E. Hilgard, S. Newcomb, M. C. Meigs, H. A. Newton, C. S. Peirce, W. P. Trowbridge.

Committee to provide a fund for the academy.—Fairman Rogers, W. B. Rogers, C. F. Chandler, O. C. Marsh, Alexander Agassiz, J. L. Smith.

Committee to verify the securities of the trust fund.—M. C. Meigs, Theodore Gill.

Committee to co-operate with the National Board of Health.—S. Weir Mitchell, George Engelmann, J. Lawrence Smith, J. J. Woodward, F. A. Walker, George F. Barker, Chas. F. Chandler, Henry Draper, Wolcott Gibbs.

Committee on Meteorology (for conference with Signal Service).—Simon Newcomb, Elias Loomis, Wolcott Gibbs, H. A. Newton, William Ferrel, C. A. Schott, S. P. Langley, O. N. Rood, C. A. Young.

Committee on Sorghum Sugar Investigations.—Benjamin Silliman, Samuel W. Johnson, Charles F. Chandler, J. Lawrence Smith.

Committee on Hydrometer Scales.—C. F. Chandler, J. E. Hilgard, Henry Morton.

MEMBERS.

Abbe, Cleveland, Washington, D. C.
Abbott, Henry L., U. S. A., Whitestone, Long Island, N. Y.
Allen, J. Asaph, Cambridge, Mass.
Agassiz, Alexander, Cambridge, Mass.
Alexander, Stephen, Princeton, N. J.
Baird, Spencer F., Washington, D. C.
Barker, George F., Philadelphia, Pa.
Barnard, Frederick A. P., New York City.
Barnard, J. G., U. S. A., New York City.
Bartlett, William H. C., Yonkers, N. Y.
Brewer, William H., New Haven, Conn.
Brown-Sequard, Charles E., 18 East Twenty-ninth street, New York.
Brush, George J., New Haven, Conn.
Chandler, Charles F., New York City.
Coffin, John H. C., U. S. N., Washington, D. C.
Cooke, Josiah P., Jr., Cambridge, Mass.
Cope, Edward D., Philadelphia, Pa.
Coues, Elliott, U. S. A., Washington, D. C.
Crafts, James M., 44 Beacon street, Boston, Mass.
Dalton, John C., 41 West Forty-eighth street, New York City.
Dana, James D., New Haven, Conn.
Davidson, George, San Francisco, Cal.
Draper, Henry, New York City.
Draper, John W., Hastings on Hudson, N. Y.
Eads, James B., Saint Louis, Mo.
Farlow, W. G., Cambridge, Mass.
Ferrel, William, Washington, D. C.
Genth, Frederick A., Philadelphia, Pa.
Gibbs, Josiah Willard, New Haven, Conn.
Gibbs, Wolcott, Cambridge, Mass.
Gill, Theodore, Washington, D. C.
Gould, Benjamin Apthorp, Cordoba, Argentine Republic, South America.
Guyot, Arnold, Princeton, N. J.
Hall, Asaph, U. S. N., Washington, D. C.
Hall, James, Albany, N. Y.
Hayden, F. B., Philadelphia, Pa.
Hilgard, Eugene W., Berkeley, Cal.
Hilgard, Julius E., Washington, D. C.
Hill, George W., Washington, D. C.
Humphreys, A. A., U. S. A., Washington, D. C.
Hunt, T. Sterry, Saint James Hotel, Boston, Mass.
Hyatt, Alpheus, Boston, Mass.
Johnson, Samuel W., New Haven, Conn.
King, Clarence, Washington, D. C.
Langley, Samuel P., Allegheny Observatory, Pa.
Lesley, J. Peter, 1008 Clinton street, Philadelphia, Pa.
Loomis, Elias, New Haven, Conn.
Le Conte, John, Berkeley, Cal.
Le Conte, John L., 1625 Spruce street, Philadelphia, Pa.
Le Conte, Joseph, Berkeley, Cal.
Lesquereux, Leo, Columbus, Ohio.
Lovering, Joseph, Cambridge, Mass.
Lyman, Theodore, Cambridge, Mass,
Marsh, George P., Rome, Italy.
Marsh, O. C., New Haven, Conn.
Mayer, Alfred M., Hoboken, N. J.
Meigs, M. C., U. S. A., Washington, D. C.
Mitchell, S. Weir, 1332 Walnut street, Philadelphia, Pa.
Morse, Edward S., Salem, Mass.
Morton, Henry, Hoboken, N. J.
Newberry, J. S., New York City.

Newcomb, Simon, U. S. N., Washington, D. C.
Newton, H. A., New Haven, Conn.
Newton, John, U. S. A.
Norton, William A., New Haven, Conn.
Oliver, James E., Ithaca, N. Y.
Packard, A. S., jr., Providence, R. I.
Pierce, Charles S., U. S. C. S., Washington, D. C.
Peters, C. H. F., Clinton, N. Y.
Pickering, Edward C., Cambridge, Mass.
Powell, John W., Washington, D. C.
Pumpelly, Raphael, Newport, R. I.
Rodgers, John, U. S. N., Washington, D. C.
Rogers, Fairman, 202 West Rittenhouse Square, Philadelphia, Pa
Rogers, Robert E., 1104 Walnut street, Philadelphia, Pa.
Rogers, William B., Boston, Mass.
Rood, Ogden N., New York City.
Rowland, Henry A., Johns Hopkins University, Baltimore.
Rutherfurd, Lewis M., 175 Second avenue, New York City.
Schott, Charles A., Washington, D. C.
Scudder, Samuel H., Cambridge, Mass.
Sellers, William, Philadelphia, Pa.
Silliman, Benjamin, New Haven, Conn.
Smith, J. Lawrence, Louisville, Ky.
Trowbridge, John, Cambridge, Mass.
Trowbridge, William P., New York City.
Trumbull, J. H., Hartford, Conn.
Tuckerman, Edward, Amherst, Mass.
Verrill, A. E., New Haven, Conn.
Walker, Francis A., New Haven, Conn.
Warren, G. K., U. S. A., Newport, R. I.
Whitney, William D., New Haven, Conn.
Wood, Horatio C., Philadelphia, Pa.
Woodward, J. J., U. S. A., Washington, D. C.
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